POWER PLANT ENGINEERING

Established Over 30 Years

VOL. XXX CHICAGO, APRIL 15, 1926 No. 8

Contents of this Issue

Page

Power for the Continental Fibre Co. Illustrated.....460
Economic Facts of Electricity. Illustrated.....465
Advantages of Automatic Boiler Control. By H. K. Blanning.....470
Water Softener Lowers Boiler Maintenance Cost. Illustrated.....472
Designing Boiler Furnace Arches. By H. C. Thayer.....473
Motor Controlled Valves Find Wide Application. By C. W. Kuhn. Illustrated.....474
Simple Approximation of Engine Water Rates. By A. F. Sheehan.....477
Worthington Builds New Diesel Engine. Illustrated.....478
Principles of Transformer Connections—V. By V. E. Johnson. Illustrated.....483
Comparison of Converters and Motor-Generators. By W. B. Snyder. Illustrated.....486
Air-Lift Pumping Pays Dividends for Oil Plant. By Dudley W. Moore. Illustrated.....488
Progress of Pit No. 4. By Frederick S. Myrtle.....489
Removing Alluvial Matter at Hydro Plants. By Henri Dufour. Illustrated.....490
Proper Filters Aid Ice Plant Operation. By Charles H. Herter.....493
Connecting Ammonia Gages. By J. F. Staley. Illustrated.494
Letters Direct from the Plant: Intermittent Steam Trap Causes Power Interruption. Pump Troubles Caused by Sacks in Line. Aluminum Paint as Cause of Trouble. Simple Device Keeps Oil off Governor Belt. Feed Water Heaters Economical in Any Plant. Can an Arch Be Flat? Illustrated.....495
Questions and Answers: Small Per Cent of Coal Energy Utilized. Comments on Corliss Engine Diagrams. Lower CO_2 with Oil than Coal. Proper Method of Applying a Quarter Turn Belt. Wetting Coal Is Advisable. Illustrated.....498
Editorial Comment: What Instruments Are Absolutely Essential? Complete Records Should Be Kept in the Hydro Plant. Sound Fundamental Preparation Is Required for Engineering Training.....500
Off Duty.....501
Electric Chain Hoist Has Ball-Bearing Load Sheave. Illustrated.....502
Mechanical Pressure Filter Has No Strainer Heads. Illustrated.....502
New Portable Drive for Power Pipe Tools.....503
Small Size Cement Gun Aids Repair Work. Illustrated.....503
Byllesby Eng. & Man. Corp. Plans 1926 Construction.....503
Portable Vacuum Cleaner for Industrial Work. Illustrated.504
Five Special Trains to the N. E. L. A. Convention.....505
Work on Baltimore's New Plant Well Under Way. Illustrated.....505
Insull Interests Plan 1,000,000-Kw. State Line Plant.....506
Union Carbide Co. Plans Hydro Development.....506
San Joaquin Light & Power Corp. to Complete King's River Project.....506
A. S. T. M. Committees Report Progress.....506
British Form New Research Organization.....506
News Notes.....507
Books and Catalogs.....508

Published on the 1st and 15th of each Month by the Technical Publishing Co., 537 So. Dearborn Street, Chicago
New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1926, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue 23,325

EDITORIAL STAFF

ARTHUR L. RICE, Editor
R. E. TURNER, Managing Editor
A. W. KRAMER, Associate Editor
CHESTER R. EARLE, Associate Editor
JOSEPH R. DARNELL, Associate Editor
RICHARD H. MORRIS, Associate Editor

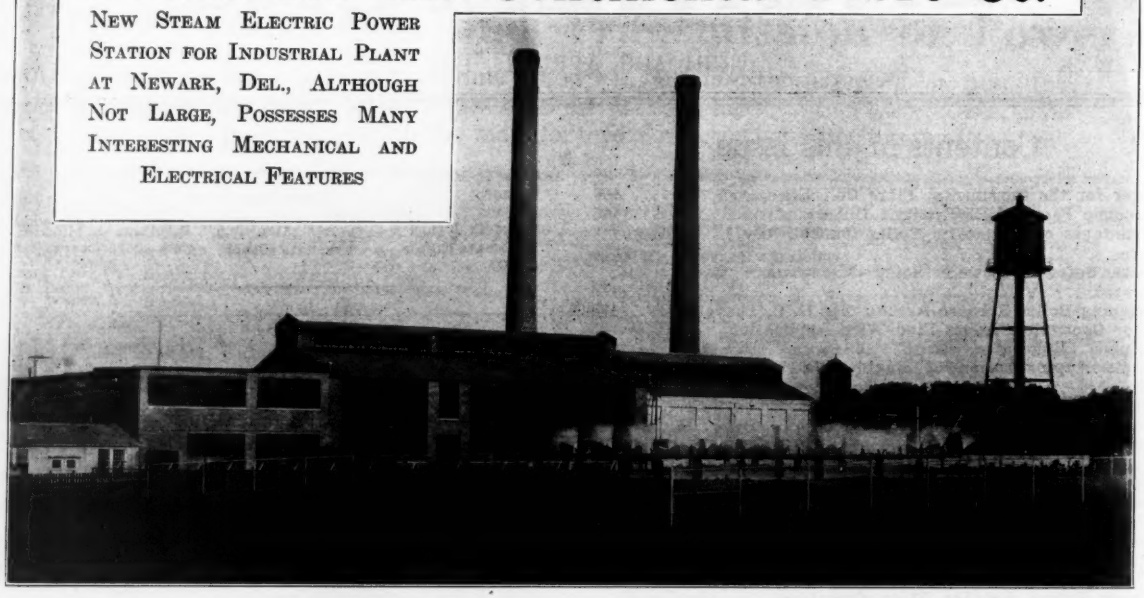
The Grave Creek Mound

IN THE SOUTHERN part of Ohio, not far from the town of Moundville, is a peculiar cone-shaped grassy hill, 320 ft. in diameter at the base and some 70 ft. high. This hill, known as the Grave Creek mound, is one of the largest relics of the American mound builders, whose strange earthworks are to be found throughout the Ohio and Mississippi Valleys. At one time it was thought that these mounds were constructed by a distinct race of highly civilized agriculturists who had lived from remote antiquity in the regions of the mounds but were eventually exterminated by nomadic hoards coming from the north. This theory, however, no longer finds support and it is now believed that the mound builders were of the same race as the Indians first met by the whites. The mounds left by these people are of various shapes, the cone-shaped ones, of which the Grave Creek Mound is a fine example, being known as altar mounds. At the apex there is usually a basin of hard clay showing the effects of fire.

Of course, all this is interesting but we don't want anybody to get the idea that it has anything to do with the picture at the top of this column. That? Oh, that's merely a view looking straight up the outside of a 250-ft. concrete chimney.

Power for the Continental Fibre Co.

NEW STEAM ELECTRIC POWER STATION FOR INDUSTRIAL PLANT AT NEWARK, DEL., ALTHOUGH NOT LARGE, POSSESSES MANY INTERESTING MECHANICAL AND ELECTRICAL FEATURES



STEAM ELECTRIC POWER plants are, on the whole, very much alike. All of them contain one or more boilers, a number of pumps, turbines or engines with generators for generating the electrical energy and a switchboard for controlling and distributing the energy produced. Of course, the design of boilers and turbines and pumps varies somewhat but the principles involved in their construction and operation are the same in a thousand other plants. It is, therefore, not in the main units that we must look for the interesting features of any power plant but in what are usually considered the more unimportant (although they are not) details of the plant. Each plant has certain individualities peculiar to its own requirements—it may be only in the way the water level in a certain tank is regulated or in the way the oiling system of an engine is arranged, it matters not how small or seemingly trivial these details are, they, all taken together, make up the difference between one plant and another.

So, in describing the new power plant of the Continental Fibre Co., at Newark, Delaware, we will concern ourselves largely with these little individualities. The boilers at the plant are much like other boilers, the turbines are of standard design, and the switchboard, as a whole, could not be distinguished from ten thousand other switchboards. It is the manner in which the boilers are set, however, and in the operation of certain elements of the electrical system that makes the boilers and the switchboard different and of which we will speak. A novel method of arranging the pumps and piping associated with the jet condensers furnishes another instance of something different—nothing radically new, it is true, but still interesting.

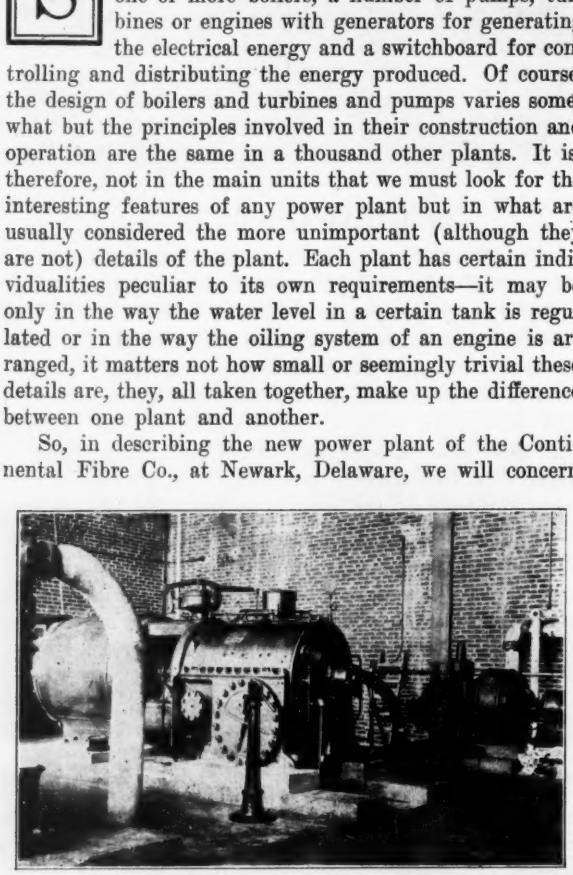


FIG. 1. THE 300-KW. REBUILT TURBINE UNIT

This plant, which furnishes all the light, heat and power used in the Newark, Del., factory of the Continental Fibre Co., consists of two boiler rooms and a turbine room. One boiler room is new, built some two years ago with the turbine room, while the other is an old boiler room, now used only for making process steam for the factory. The new boiler room supplies steam only to the turbines.

It has two 300-hp. Edge Moor water-tube boilers fitted with Huber stokers. This stoker is of the semi-automatic type, that is, coal is delivered into the hoppers by hand after which a reciprocating shelf works the coal down onto the grates. The latter are operated manually by means of levers which rock alternate grate bars. A second set of levers operates the dumping shelf at the rear end by which the ash is discharged to the ash pits. Water pressure of about 80 lb. per sq. in., supplied by a small Worthington pump, is used to operate the stokers.

Coal comes into the plant by rail, the cars discharging into coal bins in front of the boilers. It is a good grade of bituminous and needs no reduction in size so crushers are not installed. One fireman is employed who has no trouble in attending to these boilers. Coal is taken from the bins by a standard type of coal car and is shoveled directly into the stoker hoppers.

It may appear strange that the two boiler rooms are

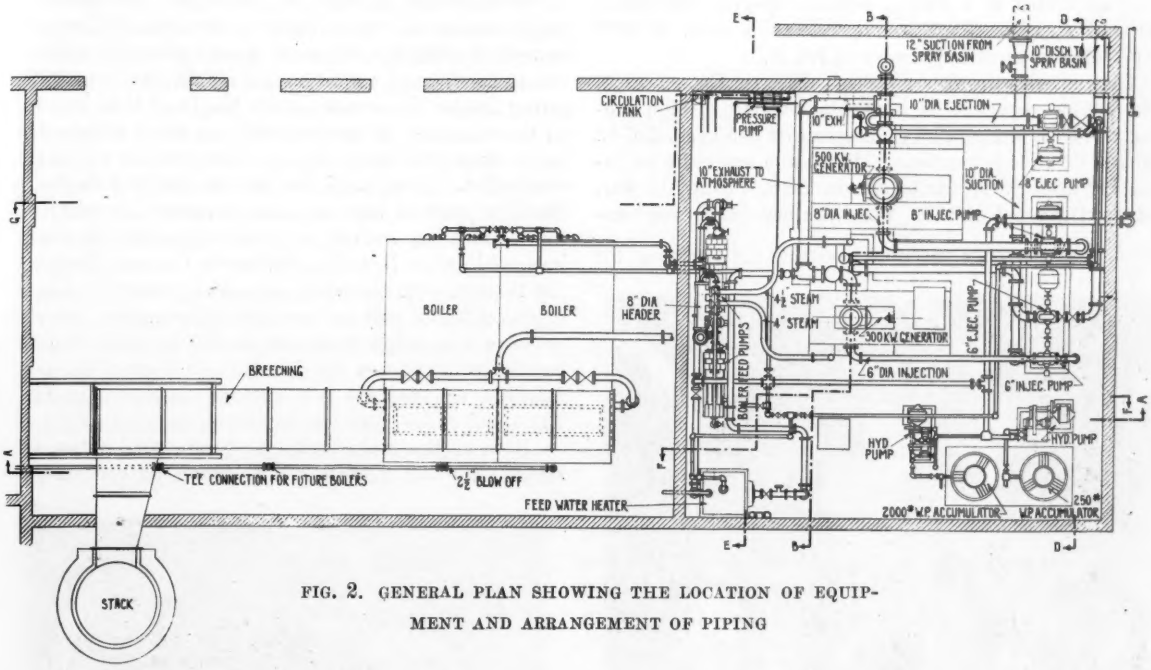


FIG. 2. GENERAL PLAN SHOWING THE LOCATION OF EQUIPMENT AND ARRANGEMENT OF PIPING

operated separately. The reason is this: before the new plant was built all boilers carried a pressure of 110 lb., the pressure at which steam is used in the factory for process work. When the new turbine was ordered, it was decided to operate at about 200 lb. So, today, there are two different pressures, 110 lb. for process work in the factory and 200 lb. for the turbines. Ultimately, they expect to do away with the old boilers, installing units similar to the new ones in their place.

A view of the new boilers is shown in Fig. 4. As is apparent from the picture, they are set unusually high considering the size of the installation. It is at least 10 ft. from the grate to the lower row of tubes. This design has been amply justified by the excellent performance. Central station practice, of course, has tended toward the use of high boiler settings for some time past but it is unusual to find this principle applied in small industrial power plants. It shows, however, that the knowledge obtained in central station practice may be successfully employed in the design and operation of the small plant—a fact not generally appreciated and too often ignored.

Each boiler has 7 units of Diamond Valv-in-head soot blowers, Foster superheaters, Reliance water columns, two safety valves and an Ashcroft steam gage. The safety valve discharge pipes rise about 10 ft. above the top of the boilers and discharge into the monitor where the steam can easily escape to the outside of the building. A steel breeching 6 ft. 3 in. by 5 ft. 6 in. in section, which runs above the boilers along the rear wall of the boiler room, connects with a 150-ft. radial brick stack at one end of the building.

Feed water, which is river water brought from the Pennsylvania Railroad system some distance away, is pumped into the boilers by either of two Worthington 7½ by 4½ by 10-in. duplex feed pumps. A Cochrane open heater is installed.

Features of the Turbine Room

At the present time, two turbo-generators are installed and in operation. There is a third unit, a small 68-kw. machine, but this is not in operating condition at present. In fact, it is practically worn out and will soon be removed to make room for a new machine of a similar type.

Of the two main units, one is a 5-stage, 500-kw. General Electric, condensing type turbine of the latest design,

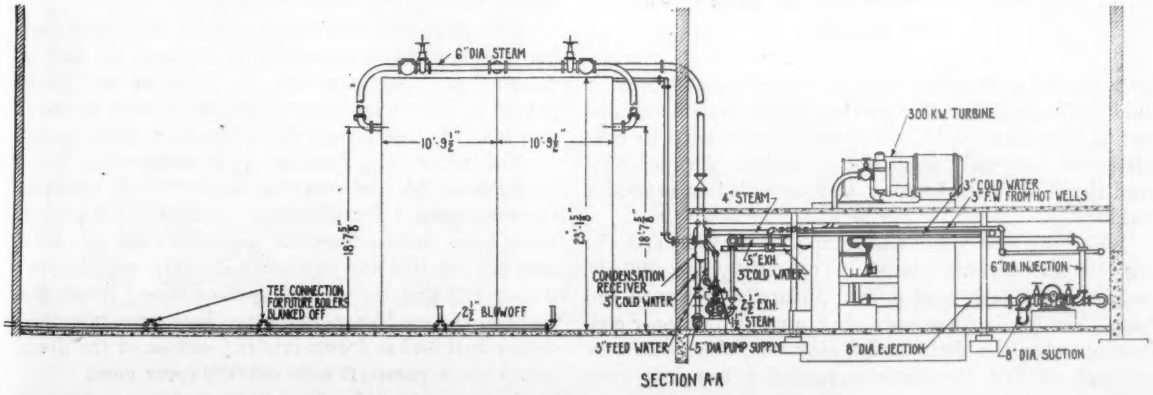


FIG. 3. LONGITUDINAL SECTION THROUGH THE PLANT

direct connected to a 240-v., 3-phase, 60-cycle alternator also of G. E. make. This unit operates at a speed of 3600 r.p.m. under a throttle pressure of 200 lb.

The second unit, also a General Electric Co. machine, is of 300-kw. capacity. It is a 4-stage Curtis turbine running at 3600 r.p.m., direct connected to a 375-kv.a., 240-v., 3-phase, 60-cycle generator. This turbine has quite an interesting history. It was bought in 1918, during the war, and until the end of 1923, when the new plant was completed, was the only machine available for carrying the

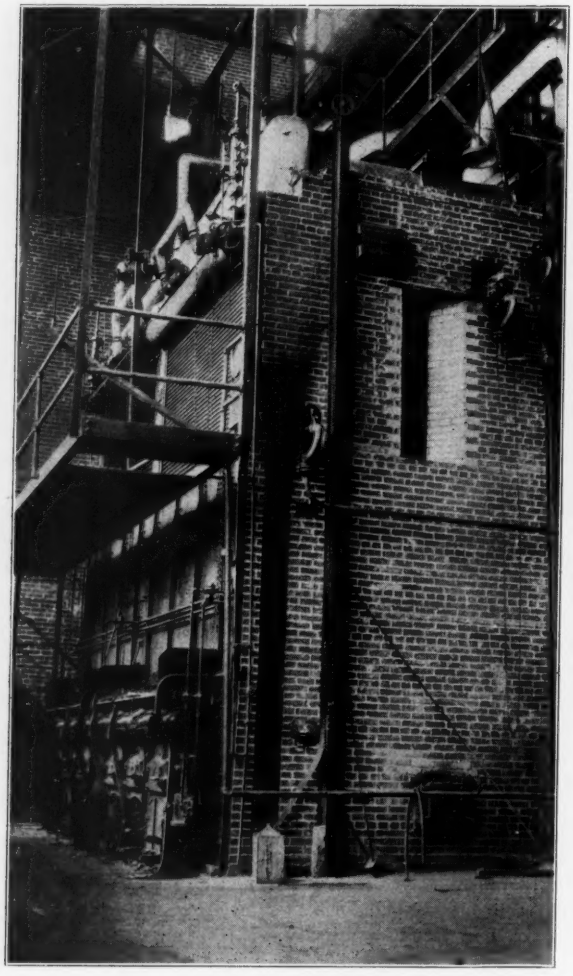


FIG. 4. THE TWO EDGE MOOR BOILERS HAVE UNUSUALLY HIGH SETTINGS

day load. As a consequence of this condition of affairs, it could not be shut down for overhauling or repairs and was kept in operation under what would ordinarily be considered an extremely inefficient condition. The machine stood the strain well, however, and prevented an expensive shutdown.

When the new plant was completed in 1923 and the new 500-kw. turbine placed in operation, the 300-kw. machine was finally shut down. Naturally, it was in bad shape. The blading was worn, due to use of improper condensing water, the shaft needed attention, clearances were enlarged, in fact the machine needed a complete overhauling.

So as soon as it could be dismantled, the entire unit, generator and all, was shipped to the Lynn Works of the General Electric Co., where it was rebuilt. The generator was in fairly good condition and might have run without giving trouble for a considerable length of time but, to be on the safe side, it was rewound and fitted with new collector rings and brush rigging. The turbine was entirely overhauled. A new shaft was put in, new split diaphragms fitted in place of the one piece elements originally used, the blading was entirely replaced and a new governor of improved design installed. When the General Electric Co. got through with the work, they had virtually a new machine. After it was re-installed in the plant, the steam pressure was raised from 180 to 200 lb. so as to run in parallel with the new 500-kw. unit. A view of the rebuilt machine, showing the new governor is shown in Fig. 1. The small 68-kw. unit can be seen at the right.

Both of the main turbines operate condensing, being set directly over Schutte and Koerting jet condensers in-

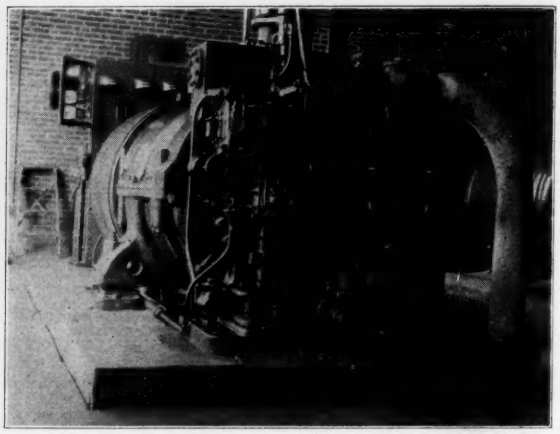


FIG. 5. AN END VIEW OF THE NEW 500-KW. TURBINE

stalled in the turbine room basement. The condenser for the small unit is the same one that was used in the old plant before the turbine was rebuilt. It merely required a new head casting so as to accommodate the different piping arrangement of the new plant.

Since there is no suitable natural source of circulating water available near the plant, water for condensing purposes is stored and cooled in a spray pond located about 100 ft. from the plant. The pump and piping arrangement of the circulating water system, shown in Fig. 6, possesses several features well worth describing.

Each condenser is provided with its individual circulating pumps. The arrangement is the same for both units except that on the large unit the injection and discharge pumps are driven by separate motors, whereas on the small unit both of these pumps are driven by a single motor.

The operation of these pumps is perhaps best described by means of the accompanying sketch, Fig. 6, which shows the arrangement for the small condenser. The injection pump takes suction from the spray pond through the common suction line and discharges directly into the jet condenser through the 6 in. injection line. After passing through the condenser, the water discharges into the condenser well and is drawn into the suction of the discharge pump which pumps it back into the spray pond.

It is necessary, for this system to function properly, to

have both of the pumps handle about the same quantity of water in a given length of time, since, if the discharge pump took more water away from the condenser well than was delivered to it by the injection pump, the water level in the well would soon fall to a point where the discharge pump would lose suction, resulting in the condenser well overflowing. It is difficult, however, to adjust the two pumps so as to handle the same amount of water. To prevent trouble due to this fact, a 4-in. bypass line, equipped with a float controlled valve, is shunted across the discharge pump in the manner shown.

Normally, a small amount of the water delivered by the discharge pump returns to the condenser well through the bypass line. As the water level in the well rises, the float gradually closes the valve in the bypass line, decreasing the amount of water delivered to the well in this manner and the level falls. As it falls, the float valve gradually opens until a balance is obtained between the water entering the well through the condenser and bypass line and the suction line.

In the case of the small condenser where both pumps are driven by a single motor, the pumps always start and stop simultaneously. When the pumps are driven by separate motors, however, as is done with the large condenser, it is necessary always to start and stop both motors at the same time. This is accomplished automatically by electrically interlocking the starting compensators.

The circulating water pumps for the small condenser are Goulds centrifugal pumps with the shafts coupled together and driven at one end by a 20-hp. Westinghouse Elec. & Mfg. Co. induction motor. The pumps on the large unit are De Laval pumps of 1600-g.p.m. capacity, driven by General Electric Co. induction motors. All

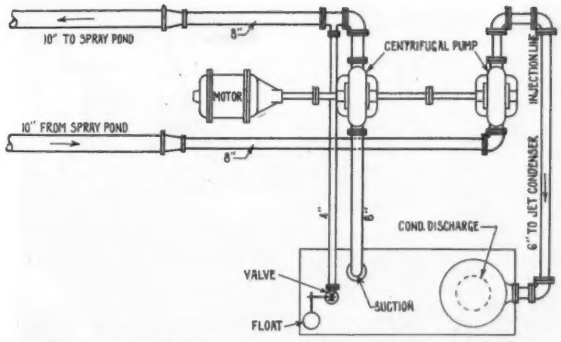


FIG. 6. SKETCH TO SHOW OPERATION OF THE CIRCULATING WATER SYSTEM

motors are started by means of G. E., type NR starting compensators.

The small 68-kw. turbine, referred to earlier in this article and which is to be replaced by a new unit of similar size, was installed to handle the night load. This machine is to be run non-condensing so that, in addition to supplying the small amount of electric energy needed at night, will also supply the exhaust steam necessary for process work in the factory.

Electrical Features

Exciting current for the two main generators is furnished by either of two G. E. motor driven exciters delivering 125-v., d.c. These units are installed in the turbine room along the boiler room wall. The fact that separately driven exciters are installed and that the small 68-kw. turbo-generator is not available, apparently leaves

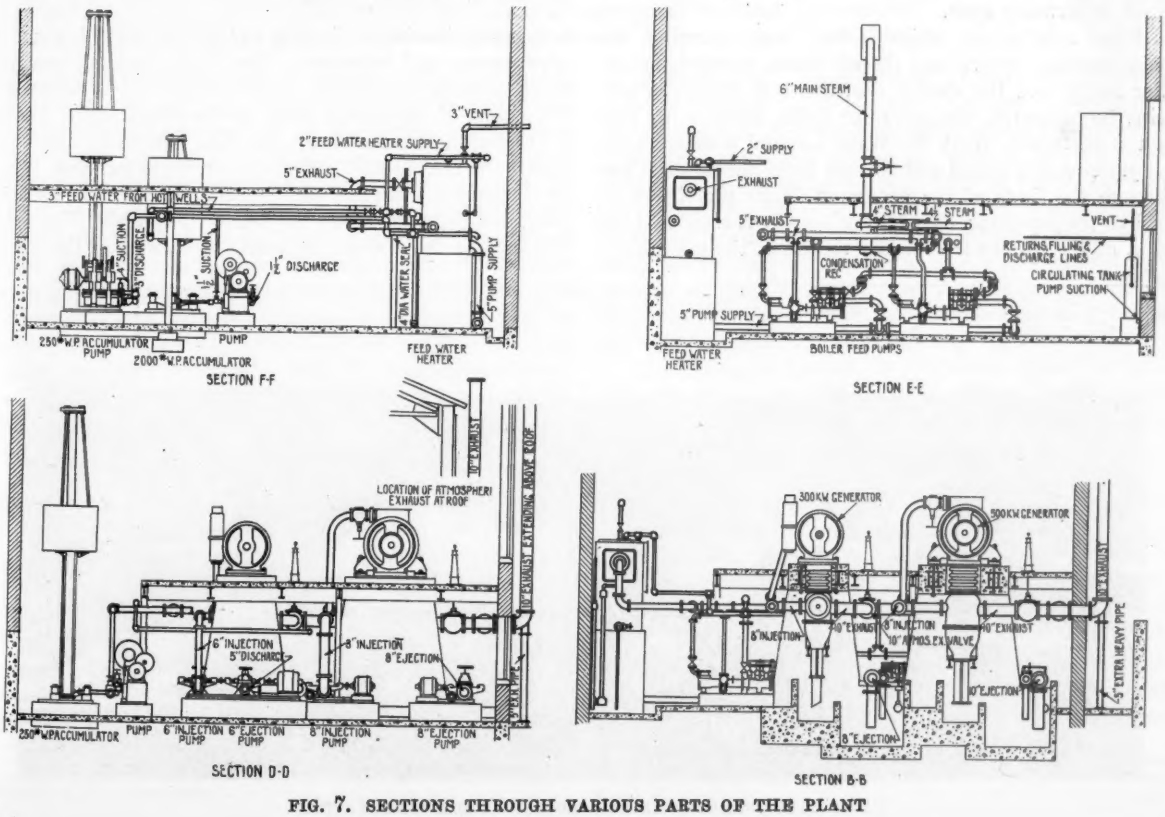


FIG. 7. SECTIONS THROUGH VARIOUS PARTS OF THE PLANT

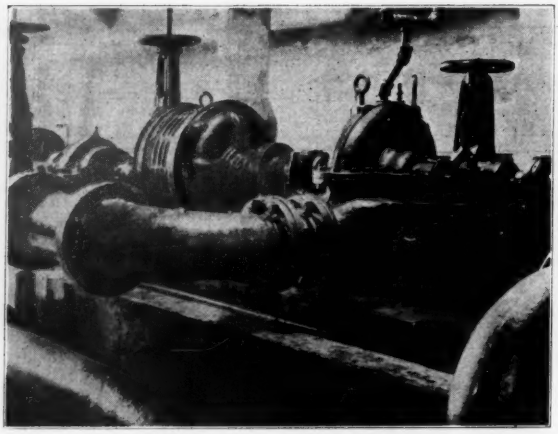


FIG. 8. VIEW OF THE CIRCULATING PUMPS ON THE CONDENSER FLOOR

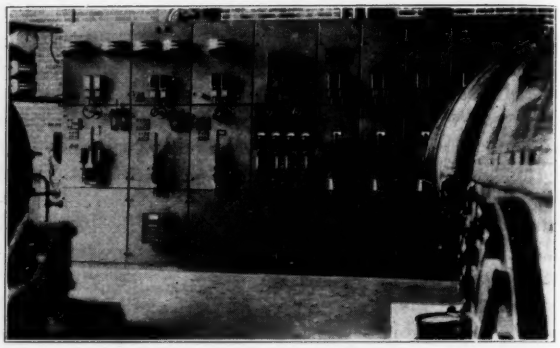


FIG. 10. THE SWITCHBOARD CONSISTS OF 9 PANELS, THREE GENERATOR PANELS, ONE EXCITER AND REGULATOR PANEL AND 5 FEEDER PANELS

the plant without means of starting up, except from an outside source. This is not the case, however, and starting is accomplished very nicely by means of a small 40-v. Edison storage battery. This, it is true, was installed when the new plant was built, more as a makeshift, but it has worked out so well that it is to be retained when the new small turbine is installed.

A simple diagram of the exciting system is shown in Fig. 11. The two exciters operate directly from the alternating current station bus and feed into a common exciter bus through three-pole knife switches. One side of the 40-v. Edison storage battery is at all times connected to one side of the exciter bus, the other side being connected to the other side of the bus through a Ward Leonard breaker which is normally open.

When starting up, which is done every morning, the main generator switch and the oil switch between the exciter motor and the station bus, are both closed. There being no current in the generator fields, however, no current is generated. Next, the Ward Leonard breaker in the battery circuit is closed and current from the battery flows through the fields of the generator. With practically no load on the generator, the exciting current is small and the 40 v. of the battery is sufficient to permit the machine to start generating. This immediately starts the exciter motors and the voltage on the d.c. side begins to build up. When it reaches the required value (which takes only a few seconds) the exciter knife switch is closed. Since the exciter voltage is considerably in excess of the battery voltage, the current inrush from the exciters into the battery immediately causes the overload coil of the Ward Leonard breaker to act, tripping it open and disconnecting the battery from the circuit.

The switchboard, illustrated in Fig. 10, consists of nine panels arranged as follows, from left to right:

No. 1. Generator panel (500-kw. unit).
No. 2. Generator panel (300-kw. unit).
No. 3. Generator panel (68-kw. unit).
No. 4. Regulator and exciter panel.
No. 5 to 9. Feeder panels.

A swinging bracket at the left end of the board holds the synchroscope and voltmeters. The Ward-Leonard breaker, which connects the battery to the exciter bus, is shown at the bottom of the fourth panel in the photograph. Above it on the middle section are the d.c. voltmeters and ammeters for the exciters, and the main knife switches. The switchboard is equipped with General Electric Co. oil circuit breakers, mounted on the rear of the panels. The field rheostat for the 500-kw. generator is located in the base-

FIG. 12. SPRAY POND FOR COOLING CONDENSING WATER

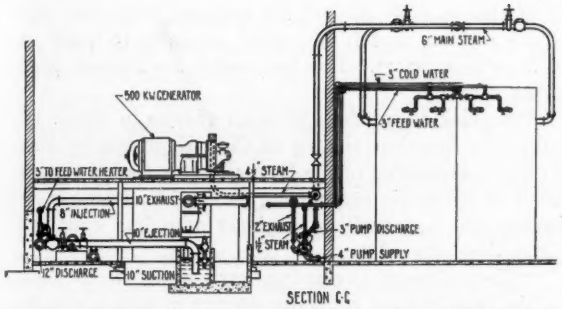


FIG. 9. ANOTHER SECTION SHOWING THE 500-KW. UNIT AND ASSOCIATED PIPING TOGETHER WITH BOILERS

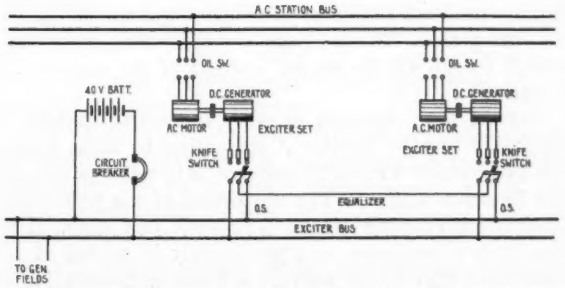


FIG. 11. SKETCH TO SHOW METHOD OF STARTING FROM THE 40-V. STORAGE BATTERY

ment while the rheostat for the 300-kw. machine is mounted on the tie rods above the switchboard.

Leads from the switchboard pass up the end well of the turbine room to the outside of the building, from which point distribution lines are carried on steel supports mounted on the various buildings which compose the factory.

Miscellaneous Facts

It may be of interest to know that the entire new plant was built without one day's loss of service to the factory. The plant was designed and constructed by the Philadelphia branch of the Austin Co., industrial engineers and builders, Cleveland, and is operated under the direction of W. C. Anderson, chief engineer of the Continental Fibre Co.

The buildings are of brick, steel and concrete, amply lighted by large windows and monitor lights. Artificial lighting is secured by means of incandescent lamps fitted in enameled reflectors with glass diffusing globes. For handling parts during periods of repair or when installing equipment, a hand operated traveling crane is provided in the turbine room.

It may be noticed from the accompanying drawings that in the corner of the turbine room or rather on the condenser floor below the turbine room that there is installed an accumulator, together with a hydraulic pump. This apparatus has nothing to do with the power plant but is used for furnishing hydraulic pressure to the factory.

In concluding this article, credit is extended to the management of the Continental Fibre Co. for privileges extended in collecting data and to the Austin Co. for supplying drawings and certain of the photographs used as illustrations.

Economic Facts of Electricity Supply*

A Discussion of the Fundamental Factors Governing the Development of Electric Power Supply Systems

IT IS EVIDENT to anybody who has studied the growth of our electricity supply systems during the past decade that centralized production of the power requirements of a community, or of a larger area, results in decided benefits for those served. Less investment is required, the use of investment is more continuous, and, because of the large capacities, economical stations of great size are possible. Going a step further, the reserve capacity required by a group of interconnected companies is less than that required for the individual companies separately, thus reducing the total system investment. All students of public utility operation are familiar with the diversity that exists in the demand for energy by various users, whose drafts are inevitably stagged in duration and intensity throughout the day, the month, and the year. The larger the system that can be operated as a unit, the greater will be the beneficial effect through increased diversity.

This is true in either case of centralized production or of interconnected operation. The interconnection of adjoining systems brings to the co-operating companies an extension and consolidation of the advantages of centralized production that each one has in its own territory.

The benefits of increased diversity are threefold. First, there is a reduction in the peak generating capacity required for a given area, with corresponding reduction of plant investment. Second, more continuous use of the plant investment is possible, resulting from a greater number of units, or kilowatt-hours, produced by the same investment. The fixed charges of interest, taxes, and depreciation to be borne by each unit of output are thus lowered. Third, the reserve capacity which has to be maintained as a substitute for other generating equipment is considerably reduced below the minimum required by a number of isolated systems serving the same territory. This, also, has the effect of reducing the total plant investment of the interconnected systems.

The saving in fuel due to large-scale operation is not only important from the cost angle but also as a conservation of the country's natural resources. This saving is partly due to the more extensive development of water powers that is now possible in modern extensive systems, and due also to the higher economies in operation of larger stations. As coal constitutes about 90 per cent of the central-station fuel, the saving may be best expressed in terms of coal. Statistics compiled by the U. S. Geological Survey show that the average coal requirement of public-utility power stations has decreased each year since 1919, starting with 3.2 lb. per kilowatt-hour in 1919 and reaching 2.2 lb.[1] in 1924. (See table and Fig. 1.) Comparing the rate for 1919 with those achieved in later years

*Abstracted from the Electric Power Survey of the Great Lakes Division made by the Power Survey Committee of the National Electric Light Association.

[1]Preliminary estimate for 1925, received as this report was going to press, indicates that this figure has been further reduced to 2.1 lb.

shows a resultant saving of 53,000,000 tons of coal in the five-year period. This tonnage is considerably more than enough to run all the central stations of the country for a year.

Of the total installed capacity in central stations in the Power Survey Territory,[2] amounting to about 4,600,000 kw., 676,000 kw., or 15 per cent is in water-power, the rest in steam stations. The proportion of the power supplied by our running streams is thus not very large. However, it is of sufficient size, particularly in several of the states (see Fig. 2), to warrant a fuller understanding of the subject. The relation between the amount of condensing water required and the coal burned in steam stations also justifies more detailed treatment.

Water-power Development

Electrical energy generated by water power in the public-utility plants of the United States is about one-

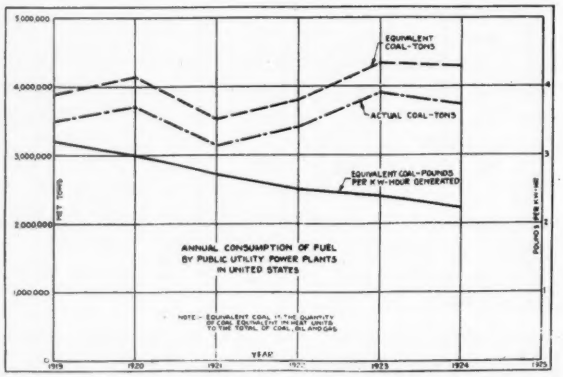


FIG. 1. CONSUMPTION OF FUEL BY PUBLIC UTILITY PLANTS IN THE UNITED STATES

third of the annual output, the percentage of water-power energy in the last six years being as follows: 1919, 37.5 per cent; 1920, 37.1 per cent; 1921, 36.5 per cent; 1922, 36.1 per cent; 1923, 34.8 per cent; and 1924, 33.8 per cent. For the four states of the Great Lakes Division, the ratio of water power to total output in 1924 was 17 per cent, and for the entire nine states of the Territory practically the same; while the Mountain States in the west, as a group, produced 85 per cent of their electricity from water power.

New water powers are being developed in the Power Survey Territory each year, but not as fast as the total load increases. The percentage of output from water-power stations is, therefore, slowly decreasing. In other words, the steam stations are increasing in capacity and output at a greater rate than are the water powers. However, the full utilization of such power streams as may be developed should be undertaken as fast as the load requirements and economic considerations in each case justify. The fact that water powers are, and always will be, only part of the Nation's power resources must not be lost sight of, and any impression which may have been created by publicity not based on a full knowledge of this matter should be corrected.

Much pertinent and important information has been presented before engineering societies recently, and some of this has so fully covered the economic and other phases of the problem that it is deemed advisable to quote some of it in this report, so as to present the clearest picture of the situation.

Following are extracts from an address in April, 1924, before the American Society of Civil Engineers by Daniel W. Mead, a member of the Power Survey Committee, professor of hydraulic engineering at the University of Wisconsin, and a consulting engineer who has built many power developments:

"The success of any hydroelectric development depends on the possibility of supplying energy in such manner and at such a price, that it will command a market and assure a fair return on the cost of the development. This principle is easily expressed and easily understood, but is difficult to apply to any concrete case. A favorable answer to this question depends on many factors which may be classified in a great variety of ways, but which are herein considered under the following headings:

1. The acquisition of suitable legal rights.
2. The command of a satisfactory power market.
3. Reasonably suitable physical conditions.
4. Favorable hydrological conditions.
5. The proper design of the works involved.
6. Economical and substantial construction.

CONSUMPTION OF FUEL BY PUBLIC UTILITY POWER PLANTS IN THE UNITED STATES—1919-1924

FROM U. S. GEOLOGICAL SURVEY

Year	Coal Short Tons	Coal and Its Equivalent in Other Fuels* Short Tons	Lb. Per Kw-Hr.
1919.....	35,100,000	38,880,000	3.2
1920.....	37,124,000	41,420,000	3.0
1921.....	31,585,000	35,240,000	2.7
1922.....	34,179,000	38,000,000	2.5
1923.....	38,954,000	43,522,000	2.4
1924.....	37,556,000	43,130,000	2.2

Coal, oil and natural gas; the oil and gas converted into coal equivalent.

7. Economical financing.
8. Rapid and economical development of business.
9. Economical management, operation and maintenance.
10. Accurate estimates of power output and income and of cost of promotion, financing, construction, depreciation, development, management, operation, and maintenance.

"These factors will vary in importance with each possible development. Any one of them, however, may be so unfavorable as to be fatal to the economic success of any particular project. There will never be a development in which all these factors are so favorable as to leave nothing to be desired; hence, economic success will be assured only when the quantity of power available and the market are such as to provide for the expense of overcoming any and all unsatisfactory conditions.

"The water power which can be developed from a given stream is subject to considerable variation, due to the character of the stream and the climatic conditions peculiar to each particular drainage area. Usually, there are one or two seasons of high water and of low water during each year. The high water in most streams will occur generally in the spring, and sometimes, also, in the fall. The dry season of summer, together with the demands of vegetation, produces low water, and in northern streams, the

[2]This territory is indicated by the area enclosed by the double black line in Figure 4.

freezing of the sources commonly results in even lower water during January and February. In addition to these variations the years differ widely.

"No one unfamiliar with hydrological studies will realize the great variations in the flow of streams from year to year. Figure 3 shows the daily stream flow of a single river (not an extreme case) for the maximum and minimum years during the last eleven years."

John R. Freeman, another noted consulting hydraulic engineer, and a past-president of both the American Society of Civil Engineers and the American Society of Mechanical Engineers, in December, 1923, addressed the Hydraulic Power Session of the American Society of Mechanical Engineers on "The Fundamental Problems of Hydroelectric Development." Some of the paragraphs answer fully many of the arguments raised by those who would urge universal development of all running rivers regardless of economics, and they are here quoted:

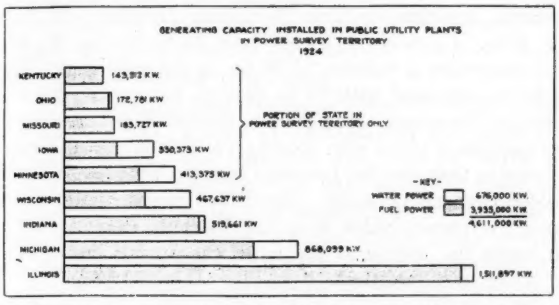


FIG. 2. GENERATING CAPACITY INSTALLED IN POWER SURVEY TERRITORY

"There are many enticing prospects of waterfalls on flashy streams, which investigation will show to have only the value that pertains to beautiful scenery, for perhaps 50 or 100 years to come.

"A site is of no more value for hydroelectric power than for a cow pasture except as its potentialities can be made to minister to industry or public welfare. And although its prospects may figure into many millions of horsepower-hours, one must first find the $100 or $200 per hp. to fit it to produce power, and before this one must know definitely what work there is that really needs this horsepower, what price it can pay per horsepower-hour or per kilowatt-hour, just how much of the power is 'firm' or primary power, and for what part of the working hours, 365 days per year, this is surely dependable under adverse conditions of flood, drought, and ice.

"There is a widespread notion that almost any waterfall can be turned by hydroelectric development into a never-ending, ever-flowing stream of gold, with small understanding of the amount of capital that must be buried beyond recall in such a venture, and on which interest must be paid or income found if capital is to be conserved.

"Those who talk of the public's being robbed of its birthright by turning over for a nominal price or rental the potential resources of flowing rivers at rapids or falls to great, soulless corporations, mostly seem to have done neither clear thinking nor accurate estimating, nor to have made a close study of any particular real prospect.

"Nor do many of these who talk loudly about development by public funds from taxation and operation under public officials as a source of profit to the public or as a means of stimulating industry by cheaper power, have any conception of the rapid rolling up of compound interest upon those parts of a large investment for whose product there is no immediate customer.

"Hydroelectric development differs from steam-electric development or other power development in that the big expenditure for water power comes mainly all in one bunch, whereas with steam it comes step by step, as needed for almost immediate use.

"On a variable stream it may be that great reservoirs can be built to regulate the flow, but there the large cost of the reservoirs has to be subtracted in determining the value of the power site. Or, it may be where river banks

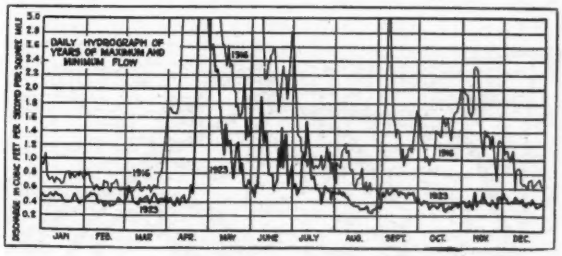


FIG. 3. DAILY HYDROGRAPH OF A RIVER

are favorable and not preoccupied by railroads, that, with the increased engineering skill and courage of recent years, a very high dam can be built at a cost of a few million dollars, to create a reservoir close to hand.

"The point which I would stress is that, when one looks at a waterfall or rapid, 'all is not gold that glitters.'

"The value of a prospective hydroelectric site is not in the water and its fall, but solely in the use to which this power can be put and the rate at which the total output can be absorbed in industry.

"One of the great problems of water power development is the education of the general public to understand the costs added by overhead, by steam reserve, by peak loads, by stand-by charges, and by distribution to the small consumer, by the expenses of measuring his draft, collecting his monthly account, and of developing in large blocks safely ahead of the demand, by maintaining a readiness to serve during drought, storm, flood, or fire, by elaborate interconnections with various widely scattered plants."

These extracts show clearly how far from simple this problem of water-power development actually is. They refer, however, in general terms to all water-power sites throughout the country and not to any particular region.

In reading descriptions of water-power possibilities, it must be remembered that the horsepower of a river generally refers to the quantity of water flowing during 50 per cent of an average year. Of course this power is not evenly distributed so as to be available for 12 hours per day of each day in the year. The periods of low water often last for months at a time, making it necessary, as stated above, to provide supplementary or interconnecting steam plants to supply the deficiency during these periods. The necessity for such steam plants was strongly emphasized during the unusual drought of 1924 in the Pacific Coast States and during the successive droughts over several years in the South Atlantic States.

Automatically operated or remote controlled water-power plants have come into existence in the last ten years,

and numbers of them are being built every year. There are several of them in the Territory. The largest installed to date in the United States has a capacity of about 16,000 kilowatts. As they eliminate a large part of the operating attendance, they are often found economical where a manually operated plant could not be justified.

Mine-Mouth Stations

As shown in Fig. 4, all but two states in the Territory have some coal deposits. The economics of mine-mouth stations, therefore, has especial interest for us. The important influencing factors of the problem are sometimes passed over somewhat lightly, even in official reports. Condensing stations having a fuel efficiency from 1.5 to 2.5 lb. of coal per kilowatt-hour require from 500 to 700

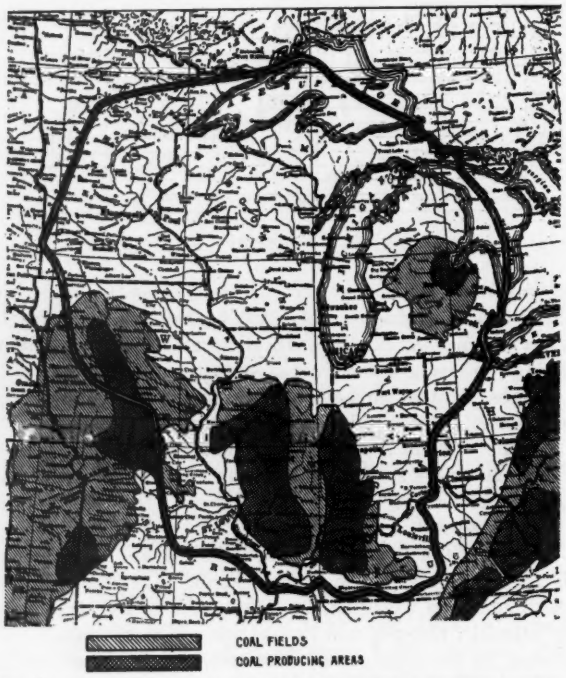


FIG. 4. COAL FIELDS IN VICINITY OF POWER SURVEY TERRITORY

t. of water, for condensing purposes, for every ton of coal burned under the boilers. The cooler this water is, the more efficient will be the work of the steam in the turbines. In other words, the cooler the condensing water, the less will be the coal burned per unit of output.

There are a number of stations of comparatively small size that resort to artificial means for cooling the water used in the condensers, and then using it over and over again. There must, however, be enough fresh water constantly supplied to make up for that lost by leakage and by evaporation. Obviously, the temperature of the condensing water thus cooled will be considerably higher than that of fresh water taken from a flowing stream, or from the Great Lakes, or the ocean. The result is poorer vacuum in the condenser. The station will, therefore, burn more coal than it would if located where an ample supply of cooling water is available. A measure of this can be obtained from the approximate average figure of 5 per cent more coal for an increase of 15 deg. F. in the temperature of the cooling water.

It is seldom that the large loads supplied from important power stations are at or near the coal mines. To get energy to market from mine-mouth stations then requires additional investment in transmission lines, and added capacity in the station to make up for transmission losses. These losses in turn require more coal to be burned at the station. The investment charges and the operating expenses thus are both increased. It is seldom that the lower cost of coal near the mine mouth offsets these increases.

There are some stations of large size in Europe where for very special local reasons cooling towers and ponds are used. One such station which has been referred to as a successful example is the Nechells Plant of the city of Birmingham, England, a municipal plant. This is not a mine-mouth station, but it uses cooling towers for its condensing water. Its installed capacity is 110,000 kw. Cooling is effected in 35 huge and expensive natural-draft, chimney-type, wooden towers. Ten more towers have been ordered, according to The Electrician (London) of June 12, 1925. The water is cooled from 92 to 75 deg. F., and this maintains a vacuum of 28 in. in the condenser. This is to be compared with 29 to 29.5 in. vacuum in the best stations elsewhere. Moreover, a condenser to provide 28 in. vacuum with 75 deg. cooling water is larger and more expensive than one for the same vacuum but provided with colder condensing water. The River Severn, with ample water, is twenty miles from the Nechells Plant. Failure to locate the station at the river was due to causes most of which were political.

The ideal site is one having ample cool water and low delivered coal costs and within economic distance from the market. The utilities are continually planning the best combinations of these essential factors for new steam-electric stations. They may be depended upon to continue to develop the most economical and serviceable plants, and if this requires locating them at the mine mouth they will be located there without governmental persuasion or intervention of outside agencies.

Relation Between Cost of Production and Cost of Delivery

Ever since the beginning of the electricity-supply industry, there has been a gradual downward trend in rates for all classes of service, interrupted for a short period during the World War and then only to a comparatively slight extent. During the entire life of the electrical industry, commodity prices have risen, and the decrease in rates has thus been accomplished in the face of a general price movement to the contrary. In no part of the period, however, has the contrast been quite so marked as during the war years and after. The Department of Labor has recently made an analysis of the rates for residence service as compared to the cost of living, and the result is plotted in Fig. 5.

In spite of the commendable reduction in rates shown by this graph, many people wonder why the rates for residence service are higher than those charged for power taken in large quantities by industries, electric railways, and other large customers.

The variation in rates for different classes of service is no wider than the requirements of the different classes of customers. The companies endeavor to base their rates on the cost of the service. That this cost of service must vary

greatly between classes of customers is made clear by a recent writer in the Journal of Electricity who states as follows:

"The power company is one concern that puts into practice the plan of 'producer to consumer' that is heralded as the method of reducing the cost of living. It carries on all of the activities which in other lines of business are handled by numerous agencies. Were kilowatt-hours 'shoes', a concern, to do the same work that the electric utility does, would have to include the cattle raiser on the great plains of the West; the railroads which haul the hides to the tanner; the tanner; the shoe manufacturer; the wholesale merchant; the railroads which haul the shoes to the various cities; the trucking firms which deliver the shoes to the retail merchant; the retail merchant; and, lastly, the parcel delivery company which delivers the shoes to the home after they have been ordered.

"The potential kilowatt-hours in the reservoirs and coal piles of the company might be compared to the hide on the steer's back; the kilowatt-hours on the switchboard of the plant as the leather coming from the tannery; and, finally, the kilowatt-hours used to light the home as the pair of shoes received at the door.

"It is probable that few have visualized such a wide variation in the amount of purchases in any other line of merchandise. The consumer who buys $1 worth per month and the consumer who buys $100,000 worth per month in most other lines of commodities are supplied by widely different concerns. In the utility field, however, the one who pays his $1 bill pays it to the same firm and deals with the same organization as the one who pays a $100,000 bill."

No reasonable person would expect that the retailer could charge the same price for his commodity as the wholesaler, yet that is essentially what is sometimes expected of the power company.

An important phase of this comparison, which should not be overlooked, relates to the difference between manufacturing cost and the retail price in any manufacturing industry. The cost of making the goods is never more than a fraction of the price which must be charged to the retail customer. In the electricity-supply industry, the cost of generation is only a small part of the cost of residence service, most of the expense being necessarily incurred in delivering the electricity to points where customers desire it. Large industrial and railway customers are comparatively few in number but absorb the greater part of the central-station output with small attendant distribution cost, often taking their energy directly from high-voltage lines and performing the ordinary distribution functions themselves. Residence customers constitute by far the great majority of all electricity users and impose on the power companies the greater part of all distribution and other service expenses, and yet they consume only a comparatively small fraction of the output. Their rate per unit of consumption, the kilowatt-hour, must thus necessarily be a retail rate. If the cost of generation could be reduced to zero, the residence rate could be lowered by only a small percentage and would then bear even a higher ratio to the wholesale rates.

Improvements in the use of coal lie not only in the steadily increasing efficiency in boiler house practice and equipment of the large modern stations, but also in the possibility of extracting some of the components from the coal before using it as fuel. The development of processes thus far has not reached a point where the extraction of these derivatives can be done with commercial success. The demand for the by-products is not now sufficiently great. The coal derivatives that are available from existing gas and coke plants provide today's market requirements. Much costly research has been done in recent years in an effort to discover new ways of treating the coal which would give a greater yield in the form of volatile oils instead of tar compounds. As there is such an enormous demand for motor spirits, it has been felt that a high yield of volatiles might result in a paying process. Following the successful introduction of so-called cracking processes for the same purpose in petroleum refining, considerable advantage might be possible from such a process applied to coal. The principal research at present is along the lines of low-temperature distillation, or coking at

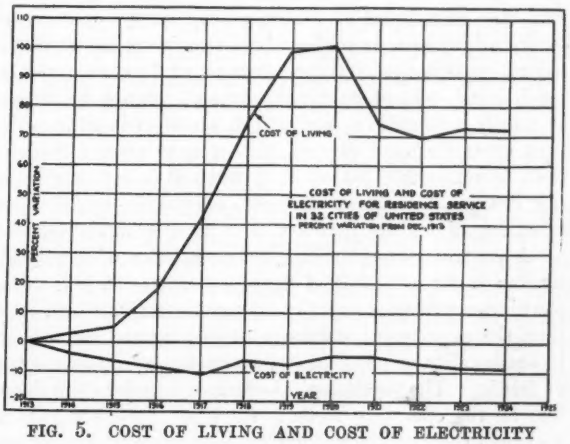

COST OF LIVING
COST OF LIVING AND COST OF ELECTRICITY FOR RESIDENCE SERVICE IN 32 CITIES OF UNITED STATES
COST OF ELECTRICITY
YEAR

FIG. 5. COST OF LIVING AND COST OF ELECTRICITY

temperatures between 500 and 900 deg. F., as contrasted to the better known coke-oven processes at temperatures around 1400 to 1800 deg. That such a low-temperature process would be a great saver of heat energy is readily apparent.

Experimentation with coal distillation is proceeding rapidly and has reached the stage where several experimental plants have been built on a commercial scale. One such plant for low-temperature distillation of coal has been ordered by a large company in the Power Survey Territory. This plant is designed to treat pulverized coal and convert it into pulverized coke ready for burning in the boilers. Various by-products will be recovered for other uses.

The ashes from power stations also have the possibility of commercial value. Ash or cinder has long been used for filling or grading, but generally has returned little or no revenue to the power company. Oftentimes when produced in large quantities it actually causes expense for its disposal. Within recent years there has developed a commercial use for ash where it is available in constant supply, as from a superpower station. This use is as an aggregate for concrete.

There has always been a demand for cinder concrete in special places like floors and sidewalks. A more recent development that promises more constant demand is the manufacture of concrete bricks or blocks. The use of cinders from Central Stations for this purpose is increasing rapidly.

Advantages of Automatic Boiler Control*

IT COMPENSATES FOR THE PERSONAL EQUATION AND BY RELIEVING THE OPERATORS OF MINUTE DETAILS, GIVES A BETTER PERSPECTIVE. BY H. K. BLANNING†

TO MAINTAIN automatic operation of a boiler or boilers, the essentials for steam generation—air, fuel and water—must be controlled with little or no human assistance and in such a way as to maintain continuous positive relations between each of these factors. If all the factors are in correct ratio at a certain boiler load but, due to different regulating characteristics, will not maintain these correct ratios at all loads, there will be a cumulative error introduced which, if allowed to continue, will entirely unbalance the system. If the regulating characteristics are of this nature then the corrections necessary from time to time must be made manually, the number of changes to be made over a given period varying inversely with the correctness of design of the control system, all other factors such as coal quality, remaining the same. A control system that requires changes of this nature is as much hand control as automatic and cannot be classed as a fully automatic system. Such a system is little better than complete hand control and in some cases worse, for faith is sometimes placed in it when it is not worthy of the charge and unless watched constantly might cause operating difficulties that would be hard to straighten out.

A control system having characteristics of regulation similar to the essentials of steam generation as well as the auxiliaries will need little or no manual adjustment, other than the adjustment necessary to compensate for changes in coal quality or physical characteristics affecting the rate of feeding. The psychological effect of a boiler control system on the operating force is startling, for after proving its worth they will be as loud in their approval as the man who pays the coal bill.

AUTOMATIC CONTROL MUST BE REGULATED BY OPERATORS

An automatic boiler control system must conform to the following requirements: (1) Regulate fuel and air in desired proportions at all loads. Desired proportion meaning such ratios of fuel and air as will give constant CO_2, or a CO_2 percentage that will vary directly or inversely with the load, this phase to be determined by the conditions to be met. (2) Must maintain steam pressure to within reasonable limits, but not necessarily a constant steam pressure. (3) Maintain speed variations of auxiliaries with minimum horsepower expenditure coincident with damper action, while changing from minimum to maximum speed. (4) Must be adaptable to any boiler loading scheme. (5) Must be adaptable to any type of auxiliary drive. (6) Must function as an actual working tool for the operator. In other words, if the operator has the responsibility of boiler operation he also must have authority over it and should not have his hands tied by inability to change the function of any of the controlled units if found necessary. (7) It must be actuated by a factor that is an index of load.

In any industry success is attained by making the duties of operators as nearly mechanical as possible. This is done by the application of automatic machines, as shown by the production and methods of any modern manufacturing plant engaged in mass production. Steam generation is mass production and the theory will apply just as well.

If it is a stoker plant the fireman only has to take care of stoker adjustments, auxiliary damper settings and keep his fires clean. If a pulverized fuel plant, he will adjust his primary air, burner air and keep his burners clean. There are other minor duties he will have to perform but the major ones will be taken care of by the automatic control, namely speed variation of auxiliaries, fuel feed speed variation and gross air flow. Distribution of air flow and changes in coal-air ratio to suit quality of coal must of course be adjusted by the operator but with automatic control in service it gives the operator more time properly to make these adjustments.

BETTER LOAD DISTRIBUTION BY AUTOMATIC CONTROL

Outstanding advantages of automatic boiler control over hand control may be enumerated: (1) It is functioning continuously. (2) It allows the operator more opportunity to view the operation in perspective by not forcing his attention to the most minute details of operation. (3) It functions for results and in all cases the cause for change is a measured actuating impulse. (4) Manual control is overtravel to a far greater extent than correct automatic control and as overtravel is inefficient, automatic control is more efficient. (5) Will actually maintain speeds and air volumes as index of fuel air ratio to within 4 per cent at all loads. (6) Gives better load distribution on all operating boilers, or if desired will operate certain boilers at maximum efficiency load and vary that of the others to suit the station output. Any other operating scheme applicable to local conditions may be utilized. (7) It will make all changes in speeds of boiler auxiliaries and boiler dampers simultaneously, something which is impossible with hand control unless there is a man at each auxiliary continuously. (8) All boilers under control will take proportionate parts of load swings, resulting in milder variations in steam temperature, furnace temperature, water level and water flow.

One of the latest developments in automatic boiler control applies the same functions to the rate of feed-water flow, by means of variable excess pressure, as are applied to fuel and air control. By means of a regulator actuated from the boiler master controller, the excess pressure may be varied essentially as the square of the boiler load. With any type of water level regulator the water level must be raised or lowered to alter the valve port opening sufficiently for the necessary rate of feed water flow. This is when operating at constant excess feed-water pressure. If, however, the valve port is maintained constant and the excess pressure is varied proportionately to the square of the velocity of water flow, which is directly proportional to the boiler output, then the water will be maintained practically at a constant level for all loads. This is a distinct advantage because the water level regulator and excess pressure regulator may be adjusted to maintain a constant water level at a point in the drums giving greatest steam liberating surface coincident with maximum water storage.

In order to overcome the tendency to unusually high

*From a paper read before the Prime Movers Committee, N.E.L.A., at Steubenville, Ohio.

†Boiler Room Supt., Penna-Ohio Power and Light Co., Toronto, Ohio.

or low water levels during wide changes in load, due to relative volumes occupied by steam and water in the boiler at different rates of evaporation, a water level regulator is advisable. For the usual changes in rates of steaming, however, the rates of feed-water flow will be so changed by changes in excess pressure that the water level regulator will move but slightly. This results in less wear on the valve, due to movement and throttling.

In the most successful hand controlled boiler plants, meters and gages are liberally supplied. These are essential if the operator is expected to know what the boiler is doing and why. In operating the boilers the fireman must balance pressures and rates of flow to get the desired result. To do this he must act promptly. If he has more than one boiler to control he will be busy making simultaneous changes in boiler loads to hold the steam pressure and at the same time holding the combustion efficiency at its best point. A properly designed automatic control will do all of these things simultaneously without any confusion. It will eliminate the thinking time of the fireman before he acts. It will obey the impulse from its master controller and move the valve, lever, or controller until the impulse is balanced by the desired reaction of pressure, speed or differential pressure.

Automatic Control Should Be Regulated by CO_2

If operating results are not as satisfactory as they should be the quicker the condition is corrected the better will be the average economy. Automatic boiler control is essentially automatic combustion control and as the per cent carbon dioxide in the flue gas (in the absence of carbon monoxide) is a measure of combustion efficiency then the control should function to maintain the desired per cent CO_2. If the control system would function by an impulse delivered by a change in this factor and at the same time control rates of heat generation, it would be ideal. This system would save fuel if for no other reason than by its speed in action, in short circuiting the balance necessary to be made between speed, pressures and rates of flow. Such a control will no doubt soon appear as the need for it is becoming more apparent every day, particularly with powdered fuel.

With ideal hand control, the operator would know at all times, from second to second, what his results were and would be changing his controls continuously to suit any new demand that might be made on his boilers. He would not adjust his controllers for position and then wait until his foreman told him to change, but would make adjustments to get the desired results regardless of the position. Automatic control will do all that the ideal hand operator can do, namely alter auxiliary speeds, air flow, coal flow, water flow and pressures simultaneously and in correct ratios one to the other and to the demand for steam.

No system of automatic boiler control is meant to replace entirely the boiler operator. It can and does stretch a single operator's territory so that he can conveniently watch more boilers than before. This results in a lower plant payroll by increasing the rated boiler horsepower per operator, but the plant is still under the eye of operators. With automatic control and the operator taking care of three boilers, he will have less work to do than if he were operating two boilers on hand control and the operation will be smoother and more efficient. The control system should be built and installed with the idea of making it the most reliable tool of the operator. He should be taught to use it intelligently and be given the idea that if properly used his work will be easier and the results better. Once he has become accustomed to his new tool he will find it a valuable aid and will praise it accordingly.

If any steam plant were operating at a load demand requiring a constant rate of heat generation and the factors entering into the case, such as feed-water temperature and fuel quality remained the same, any boiler could be set to maintain maximum possible efficiency by hand. This requires time, however, so that if the demand changes then all the controls must be reset at a different plane to maintain the same efficiency and steam pressure. However slight this change may be, it still is necessary to change the rate of heat generation or the steam pressure will not be held. This takes more time and with a variable load these changes are likely to come so frequently that no sooner is one adjustment made than another is required. If the changes are all made promptly and in the correct ratios, there is no difficulty, but if the load is changing continuously it is not possible for any man to make all the necessary changes as fast and as accurately as required. The answer is to give the man an automatic control system that will do all that he can do, but faster and more efficiently.

Automatic boiler control will meet emergencies in a steam plant better and cheaper than hand control. If the load is lost or a sudden emergency load is thrown on the station the automatic control will function with a speed proportional to the load change and bring all auxiliaries to the maximum or minimum speed at once without any human aid. This is a decided advantage as it allows the operators to attend to more pressing duties incident to the emergency.

In any type of variable speed drive it is difficult to establish any definite relation (except in a general way) between valve position, controller position or lever position, and speed or pressures. It has been shown that the same difficulty is found in establishing a ratio between damper position and rate of flow when the draft or pressure head varies. If the heads, load or torque, steam pressure and temperature on the auxiliary drive would remain the same, these relations could be definitely established and a regulator that regulated only for position would be sufficient for the need. But unfortunately this is not the case and it sometimes presents a confusing problem to operators. He might say, "Yesterday all my control devices were in exactly the same position as today and the results were good, but just look at the result today." Proper automatic control does not function for position, it functions for results, balancing cause and effect or impulse and reaction to attain an equilibrium within itself. Its cause for change is its actuating impulse and in proportion to it.

The design of proper automatic boiler control must be flexible enough to keep in step with operating characteristics of the machine it controls. It can compensate for chimney action, delayed action in speed change of auxiliaries, or introduce a step by step delayed action sometimes necessary in automatically controlling chain grate stokers. The advantage of doing these unusual things automatically is that once the control has been set to take care of the condition it will perform the same each time. It is difficult to train an operator to do exactly as he should at all times.

SAVING IN EQUIPMENT BY USING AUTOMATIC CONTROL

One of the phases of automatic control seldom considered is that if the plant is definitely designed for proper functioning of the automatic apparatus, there will be considerable saving in the first cost of station auxiliary equipment. For example, at our Toronto station all auxiliaries are electrically driven except two oil pumps and one emergency boiler feed pump. All electrical drive is effected either by constant or variable speed induction motors. As can be well realized by adapting induction motors to the variable speed drives, certain difficulties were encountered but a considerable saving was made in first cost of plant equipment and electrical complications incident to direct current drive were avoided. This induction motor type of drive is sensitive to load changes and for a given controller setting, speed variations will go as high as 25 per cent. This condition is now being handled successfully by our system of centralized automatic boiler control by regulating for results regardless of controller position.

Our boiler plant auxiliary layout consists of individual forced and induced draft fans for each boiler, one motor per boiler driving 12 coal feeders and controlling secondary air and uptake dampers. The primary air fans are connected on the discharge side of the fan and the pressure is controlled by hand. The centralized system of combustion control consists of one master controller actuated by steam pressure change, from which impulses are sent to the individual regulators by static air pressures which vary inversely with the steam pressure changes. Each forced and induced draft fan, uptake damper, secondary air damper and coal feeder is controlled by an individual regulator as well as each one of the three boiler feed pumps. Each regulator controlling like auxiliaries receives the same actuation from the master, hence dividing the work between the individual boilers. Provision is made at the master controller for changing the individual coal feeder speeds to compensate for changes of coal quality, or for anything that affects the rate of coal discharge per revolution of the screw, such as moisture or wearing of the feeder screws. At the present time these changes in coal feeder speeds relative to air flow are controlled by hand at the master controller but provision is made for controlling this factor automatically by connecting the automatic control of the coal feeders to an electric CO_2 meter.

Water Softener Lowers Boiler Maintenance

INSTALLATION OF HOT-PROCESS SOFTENER IN M. C. R. R. POWER PLANT AT JACKSON, MICH., REDUCES TIME OF BOILER CLEANING FROM 21 DAYS TO 4 DAYS

AT THE POWER PLANT of the Michigan Central Railroad at Jackson, Mich., some interesting economies have been effected by the installation of a hot process water softener. Figures obtained several months ago show a saving of approximately $3500 a year in cost of cleaning boilers alone to say nothing of the improvement in boiler operation brought about by the use of softened water. The power plant contains six 125-hp. Babcock & Wilcox boilers, operating at 140 lb. pressure, fired by Green chain-grate stokers, which burn miscellaneous coals. These supply steam for driving air compressors and pumps, for supplying the air and hot water requirements of the large shops and yards of the Jackson plant.

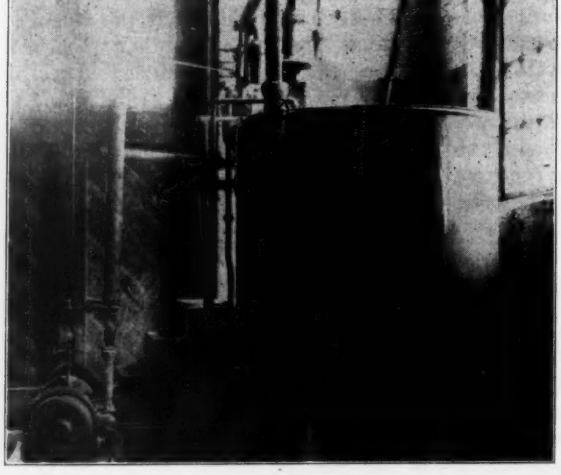


FIG. 1. MOTOR-DRIVEN CENTRIFUGAL PUMPS, AT LEFT, PUMPS SOLUTION MIXED IN THIS TANK TO TREATMENT TANK

Reciprocating boiler feed pumps supply the boilers with water. Before the softener was installed, the analysis of this water was as follows:

Raw Water	Grains per U. S. Gallons
Calcium Carbonate	7.10
Magnesium Carbonate	1.92
Silica	0.42
Iron Oxide and Alumina	0.05
Sodium Carbonate	0.75
Sodium Sulphate	2.68
Sodium Chloride	0.40
Volatile and Organic	2.21
Total	15.60

To soften this water, a standard type of Cochrane hot-process softener, with a capacity of 10,000 g.p.h., was installed to treat the water with lime and soda ash. This softener consists of a chemical solution tank with appropriate motor-driven chemical pumps, as shown in Fig. 1, and a large reaction tank. Chemicals are mixed in the solution tank, and pumped into the larger tank, where the water is softened, sludge being drawn off at the bottom and softened water at about the middle of the tank. The boiler feed pumps, part of which are shown in Fig. 2, take the treated water from the treatment tank at 212-215 deg., a Cochrane recording thermometer being installed to record its temperature.

Under ordinary conditions, it is found that 0.1 lb. of soda ash per 1000 gal. of water and 1.45 lb. lime per 1000 gal. are the proper proportions of chemicals. A water sample from the softener is analyzed every 3 hr. by the chief engineer; comparison of the tests with a special chart furnished by the softener manufacturer tells him whether to change the proportions of the chemicals or not.

As a result of the use of the above softener a substantial saving in costs of cleaning boilers has been made. Previous to its installation, it took three men at 50 cents an hour, or $12.00 an 8-hr. day for a period of 21 days, to clean a boiler and get it into service. This is $252 for one boiler for one cleaning. For three cleanings a year, the cost was $756 per boiler or $4536 for the six boilers.

Using softened water, it is necessary now only to wash out the boilers; tubes rarely need to be renewed or turbined. On account of the load conditions, boilers are now washed out twelve times a year, as it is possible to have one boiler out of service all the time; after washing, this boiler is held as a reserve. One washout requires two men for eight hours at 50 cents an hour or $8.00 and one man at 40 cents an hour for two hours or

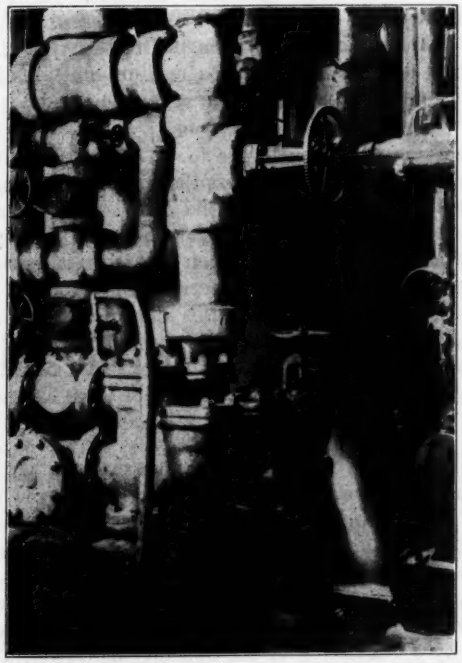


FIG. 2. BOILER FEED PUMPS DRAW CLEAR SOFTENED WATER FROM TREATMENT TANK

$0.80, making a total cost of $8.80 for one washout of one boiler. Boilers are now washed 12 times a year and the total cost for the six boilers is $8.80 × 12 × 6 = $633.60. In addition, two men for 3 days at 50 cents an hour and a helper are required to complete the washing job on all six boilers at a cost of $28.80. For 12 washings, this brings the grand total cost of cleaning the boilers up to $979.20 a year. The resulting saving in cost of cleaning boilers is $3556.40 a year.

C. A. Potts is chief of the power plant of the M. C. R. R. at Jackson and J. A. Adams is master mechanic, in charge of yards and shops.

IT IS NEVER advisable to increase the size of fuses in a line which continually burns out fuses without first finding out the reason for the frequent burnouts, and making sure that there is no ground, short or overload. Failure to do this may result in expensive burnouts of motors, danger of fire or even loss of life.

THE BREAKING STRENGTH of manila rope in pounds is 720 times the circumference in inches squared.

Designing Boiler Furnace Arches

BY H. C. THAYER

WHILE arch construction is as old as the modern type boiler, the furnace arch was not given serious consideration until the introduction of the water tube boiler and chain grate stoker. Originally the arch used with Stirling boilers consisted of two separate arches, the ignition arch being the sprung type and the baffle arch which was placed above and in front of the ignition arch, also of the sprung type. The ignition arch was installed to give a rapid ignition to the fuel, while the baffle arch was used to deflect the combustion gases into the first tube tank as low as possible in order to obtain quicker heat absorption and longer flame travel.

In 1901, W. M. Green placed the first flat arch on the market. Introduction of this arch caused serious thought to be given to this problem and resulted in several single suspension arches being designed and marketed. It was not, however, until 1917 that a double suspension arch was patented by Michael Liptak.

FLAT ARCH BETTER THAN SPRUNG TYPE

More general use of chain grate stokers in burning low grade fuel has caused rapid advancement in the design of flat arches. The necessity of sustaining ignition, together with the gradual increase of fuel and labor costs, has caused an intensive study to be made of the fundamentals involved. It was found in the early stages of flat arch design that sprung arches were greatly limited in their scope of operations, not only in regard to construction difficulties but also due to combustion limitations. Another adverse condition was the problem of air sealing, always present on account of the separate curtain wall support and in some cases the need of secondary arches. The flat suspended arch has remedied these conditions to a considerable extent because the limitations as to height above the fuel bed and the length are practically removed. In addition, the flat ignition surface permits operating with an even fuel bed and gives ideal burning conditions.

Proper ignition and sustained combustion of the fuel is the main function of the furnace arch and it has been due to the lack of knowledge of the technique of combustion under arches that until recently development was slow. When designing an arch there are many problems to be considered in order to get maximum efficiencies and life, these problems being governed by the fuel to be burned, rate of combustion, provision for the expansion and contraction of the assembled arch, selection of proper refractory and means of making easy repairs. In locating the arch, the kind of fuel burned, high or low volatile percentage in the fuel, moisture, ash and sizing, must be considered. The location is affected also by the stoking equipment—whether natural or forced draft, principle of draft control and range, and also by the boiler capacity to be obtained.

Complete combustion of the fuel must be effected in the furnace before heat transfer takes place on the heating surface of the boiler. This means that the arch must be properly located completely to burn out the fuel refuse and effect an intimate mixture of the products of combustion at the point of maximum temperature. Burning anthracite coal on traveling grate stokers requires a much greater arch area than when burning bituminous,

because it is much more difficult to ignite due to its low volatile content. When burning coal with natural draft, the arch blocks should be manufactured with a porous structure and a soft clay bond but with forced draft, especially if there is a positive pressure in the furnace, the arch blocks should have a close texture, fine grain, and be hard burned to withstand the abrasion of the fine fuel dust and the penetration of alkalies.

There is no exact or precise method of determining the proper positions, length and pitch of fire arches. The only available guide is trial and experimentation. In standard practice, however, certain relations have been developed as the result of actual tests and these results will be considered in this instance. The function of the ignition arch is to produce as intense a heat reflection at the point of ignition as possible. The temperatures obtained partially depend on the size and characteristics of the fuel, but mainly to the air supply over this area. In natural draft installations these possibilities are limited due to the latter reason. With this type of draft the most effective distance between the ignition arch and the fuel bed is from 6 to 7 in. Under forced draft the larger volume of gases requires a greater space; it is proportional to the amount of increased fuel burned per square foot, per hour. The figures given above apply to a combustion rate of 40 lb. of free burning coal per square foot per hour and an 8-in. fuel bed.

Arch Height Governed by Variable Conditions

The height of the main arch should be such that the heat reflection intensity is sufficient to insure continuous combustion for the full length of the grate, and in addition provide sufficient volume for a complete mixture and easy flow of combustion gases. This height is governed not only by the maximum combustion rate but by the characteristics of the fuel. Under a normal natural draft rate of 40 lb., the most effective height is between 14 and 20 in. at the front end, but this would require a steep pitched arch which does not permit mixing the gases. These objections are overcome by raising the front end to the maximum height of 20 in. and using a pitch of 1 in. per foot.

Under forced draft conditions additional furnace volume is required on account of the increased coal rate, temperature and air distribution. With this type of draft and with average coals having a medium amount of volatile matter, the average height above the grate is from 4 to 5 ft.

There are so many things to be considered in selecting the furnace arch that unless the engineer is thoroughly conversant with the subject, he had better submit his problem to the manufacturer for solution. The proper design, construction and location of arches is a scientific problem and should be given serious consideration.

Motor Controlled Valves Find Wide Application

Systems Developed for Central Station Open Up Wide Field in Industries. By C. W. Kuhn*

IN THE past 5 yr. there has been a tremendous increase in the use of motor operated valves. This has been brought about by a realization of the marked advantages of such control and improvements in the apparatus offered.

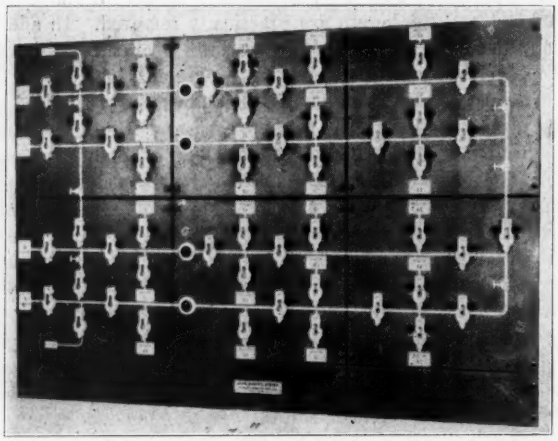


FIG. 1. CONTROL BOARD OF MODERN CENTRAL STATION ARRANGED AS MINIATURE DIAGRAM OF STEAM PIPING SYSTEM

Modern plants are designed to take advantage of this equipment.

All important steam and hydraulic valves of any size in modern power plants are now motor operated. A similar condition is coming into existence for modern water works and municipal high pressure fire protective systems. In general, it might be stated that the use of motor operated valves is becoming common practice wherever the importance of the valve and frequency of operation justifies the initial expenditure.

Central stations were perhaps the first to demand and use motor driven valves. This was, no doubt, brought about by a realization of the difficulty of closing a break in a live steam line. Such a break represents a great hazard to personal safety, the possibility of considerable property damage and the always present danger of long service interruptions.

The general demand for motor driven valves in central stations is undoubtedly due to a realization of their many and marked advantages, some of which are listed below:

1—Lessens hazards of employes.
2—Protects property from danger due to difficulty of shutting off breaks quickly in high pressure steam lines.
3—Allows of control from remote locations.
4—Permits control of valve from any number of control stations.
5—Permits automatic operation by float switches, pressure regulators, etc.
6—Valves can be operated in much shorter time than by hand.
7—Reduces labor required.
8—Permits inaccessible location of valves.
9—Centralized control of all or any group of valves may be had.
10—Two or more valves can be operated simultaneously from a single control station.

*Development Engineer, Cutler-Hammer Mfg. Co., Milwaukee, Wis.

In the early stages of their development motor driven valves were regarded as a form of insurance. It was felt that the increased initial investment was justified because of the safety features alone and anybody who has seen a break in a large, high pressure steam line can realize the advantage of being able to close off the line leading to the break from a remote and safe location. In such an emergency the importance of quick and positive closure cannot be over emphasized. Hand operation under such conditions is almost impossible and long interruptions of service may result.

While these advantages have lost none of their significance, improvements in equipment and control systems have enhanced the economic value of motor driven valves. In most installations these features now justify the investment.

Motor Characteristics Important Consideration

The conditions surrounding valve operation represent a peculiar duty cycle for the motors. The normal load or normal operation is made with an approximate pressure balance on the valve. This, therefore, represents light load for the motor. Only in emergencies are high velocity heads encountered. It is the emergency condition that requires the high torque or maximum load and makes it absolutely necessary that the motor units have sufficient torque to operate the valve under such conditions.

Torque requirements for valve operation are such that the series type of motor has the most suitable characteristic. In emergencies it will develop very high torques. Even under these conditions, the greater portion of the operating cycle is made at light, or comparatively light, loads and here the series type motor operates at fairly high speed with a resulting decrease in the time of valve closure. The series motor, when properly designed, offers similar advantages in both a.c. and d.c. service.

Additional advantages of the series type a.c. motor compared with other standard a.c. types is that when properly designed it is suitable for a wide range in frequency, is easily controlled and requires a minimum number of wires.

In designing special motors for valve operation, it is possible to obtain a small, high-torque motor, which is the equivalent of a much larger standard motor as measured from the standpoint of time required to operate a given valve under normal condition, or, by the maximum size valve which can be operated without exceeding a given temperature rise on the motor.

There is an important characteristic in connection with the operation of gate valves used for high temperature steam which must be considered. Such valves if closed when hot, frequently stick when cold, due to contraction of the ways on the gate. If motor driven units are not supplied with a large factor of surplus torque under these conditions, they may fail to operate.

Frozen Valves Started by Sudden Blow

One effective method of overcoming this is by the use of what is known as "the hammer blow effect." This can be obtained by allowing sufficient lost motion in the reduction gearing so as to enable the motor to reach a considerable speed before picking up the load, or by the use of proper clutching arrangements.

The motor driven unit may utilize a clutch which is energized at the same time as the motor. The motor, being of the high speed series type, comes up to speed before the clutch has sufficient time to engage, resulting in a hammer blow which is sufficient to start any valve which can be operated by the unit.

The safety or slip clutch has some advantages in connection with certain types of valves but is open to objections in connection with gate valves on high pressure steam lines. The prime essential for this service is the ability to close the valve in an emergency. There are a number of variables entering into the torque which can be transmitted by a slip clutch. The co-efficient of friction is likely to vary over a wide range, depending upon the condition of the surfaces, wear of the mechanism and pressure adjustments. If the valve freezes as described above, the clutch may slip and prevent operation. Furthermore it is impossible to make effective use of the hammer blow feature.

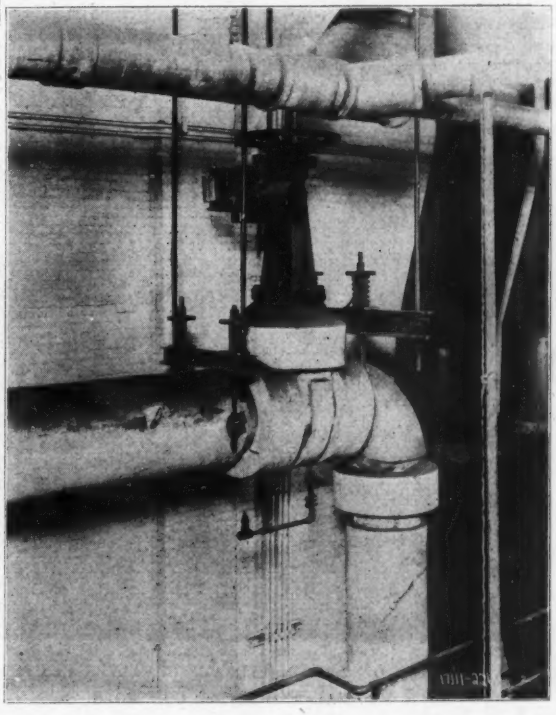


FIG. 2. SHOWING MOTOR DRIVEN VALVE IN INACCESSIBLE LOCATION ON STEAM HEADER

In general the motor driven valve consists of a motor, a gear reduction and a limit switch. They are divided into two classes, depending upon the drive used. One type has the motor and drive built integral with the valve. The other uses a separate unit which can be attached to standard valves.

Speed reductions are obtained by a variety of methods. Some utilize a worm in connection with planetary or spur gears, others a worm or spur gear reduction only. In general spur gears are more efficient but the noise of operation may be objectionable, particularly if high speed motors are used.

The limit switch of which there is a wide variety is used to stop the unit at either end of the travel. Some types on the market are designed to handle the motor circuit directly, while others are used only to operate control circuits which in turn disconnect the motor from the line.

In general, no starting resistance is used with the first type and when starting the heavy current inrush, especially in connection with the d.c. motors, is severe on the switch contacts. Arcing may result if the unit is operating under heavy load and under some conditions may hang on a sufficient length of time to result in inaccurate closing of the valve.

Early units were criticized because the motor and drive drifted after the unit was tripped by the limit switch. This resulted in excessive strain on the valve, or, if the motor were operating under heavy load, in failure to close tightly. This is now taken care of by positive declutching devices which eliminate the variable of drift or by special slowdown and electrically stopping controllers.

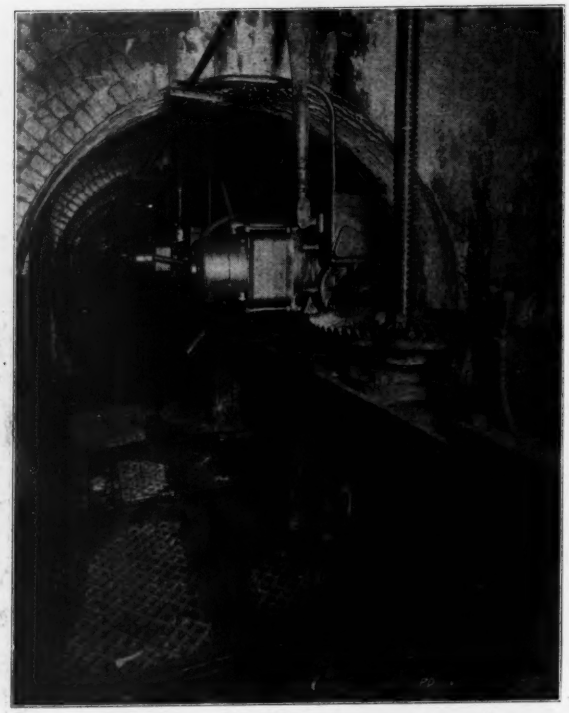


FIG. 3. DETAILS OF LARGE HYDRAULIC VALVES SHOWING BOTH MANUAL AND MOTOR CONTROLS

It is essential that motor driven valves be arranged for hand operation in cases of failure of power or for testing and setting of the limit switches. It should be possible to operate the valve by motor immediately after hand operation without resetting of limits and the arrangement must be such that when the unit is hand operated the limit switch setting is not changed. No declutching should be necessary and it should not be possible for a careless workman after hand operation to leave the valve in such a condition that it cannot be operated with the motor in case of an emergency. Several motor driven valve makers have incorporated into their design a structure which permits hand or motor operation without declutching or other special operation when changing from one type of control to the other.

The use of a separate unit attached to the valve has the advantage over the motor drive built integral with the valve. The same unit may be used upon a number of different makes of valves and in the past such units have been used for applications other than valve operation such as gear reduction, to operate screwdowns in steel mills, large windows in factories, closing of coal chutes, and a variety of other miscellaneous applications.

Marked advances have also been made in the control systems used. Originally, the control system consisted of a single reversing controller with lamp indication. Most systems on the market now permit operation from a number of points. One system is arranged so that the valve can be closed regardless of the position of the control at the other stations. In other words the man who thinks the valve should be closed is master of the situation. Some systems embody what is known as a master station. A valve closed from the master station cannot be operated again until this station is released by hand. When making repairs this provides safety for the workmen without the necessity of making changes or disconnecting the control leads.

The field for motor driven valves and valve units is being rapidly broadened. New applications are being found, not only in central stations, but throughout the industries complete control systems are being perfected and these will undoubtedly permit new applications and open up fields as yet undeveloped.

Charging Storage Batteries

By Claude Brown

The normal charging rate of a storage battery should be the same as the 8-hr. discharge rate specified by the manufacturer. The charge should be continued uninterruptedly until complete; but if continually carried beyond the full charge point, unnecessary waste of energy, a waste of acid through spraying, a rapid accumulation of sediment and a shortened life of the plates will result. At the end of the first charge, it is advisable to discharge the battery about one-half and then immediately recharge it. This operation should be repeated two or three times and the battery will then be in condition for regular use. It is advisable to overcharge the battery about once a week, in order that the prolonged gassing may thoroughly stir up the electrolyte and also to correct inequalities in the voltages of the cells. If the discharge rate is very low, or if the battery is seldom used, it should be given a freshening charge weekly.

A complete charge should be from 12 to 15 per cent greater in ampere-hours than the preceding discharge. The principal indications of a complete charge are: (1) The voltage reaches a maximum value of 2.4 to 2.7 v. per cell and the specific gravity of the electrolyte a maximum value of 1.2 to 1.4 per cell. If all of the cells are in good condition and the charging current is constant, maximum voltage and specific gravity are reached when there is no further increase for ¼ or ½ hr. (2) The amount of gas given off at the plates increases, and the electrolyte assumes a milky appearance or appears to boil. (3) The positive plates become dark brown in color and the negative plates light gray.

Nobody has ever been smart enough to think of a good excuse for using a sledge with a loose handle. There isn't any, avers the National Safety Council.

Losing one's temper is the first step toward losing an argument or a job.

Simple Approximation of Engine Water Rates

CALORIMETER USED TO DETERMINE TOTAL STEAM FLOWING THROUGH CYLINDER. BY A. F. SHEEHAN

FOR approximating the water rate of compound engines, either condensing or non-condensing, the following formula has been developed and found to give accurate results in all cases where the engines are supplied with superheated steam. Under some conditions the formula can be applied to saturated steam conditions with reasonable accuracy.

$$\text{Steam per i.hp. hour} = \frac{2545}{H_1 - H_2} \times \text{i.hp. of high}$$

pressure cylinder ÷ total i.hp. of both cylinders.

The formula is evolved as follows:

2545 = B. t. u. equivalent of one hp.-hr.

$H_1 - H_2$ = Heat extracted per pound of steam in high pressure cylinder only.

Where superheated steam is used the value of H_1 is found by readings taken from an accurate steam gage and a thermometer located at the throttle. From a steam table the total heat at the corresponding pressure and superheat can be found.

The value of H_2 is found by using a throttling calorimeter which can be made from pipe fittings if a standard calorimeter is not available. Steam from the high pressure exhaust, usually from 10 to 15 lb., enters the calorimeter and is discharged to the condenser. Two thermometers are required with the calorimeter, one on each side of the orifice. After determining the degree of superheat and the vacuum on the low pressure side, the steam table can be used to give the exact heat content of the high pressure exhaust.

The water rate of the high pressure cylinder alone would be $\frac{2545}{H_1 - H_2}$ if considered as a separate non-condensing high back pressure engine. Then the total steam flow through the engine is the product of the water rate of the high pressure cylinder times the i.hp. of that cylinder. This figure divided by the total horsepower of both cylinders gives the water rate of the entire engine.

As an example, take an engine which shows an indicated hp. of 452 in the high pressure cylinder and 488 hp. in the low pressure cylinder, with an initial steam pressure of 145 lb. gage, 50 deg. of superheat, 12 lb. receiver pressure, and a vacuum of 25.7 in. A glance at the steam tables shows H_1, the total heat of the entering steam, to be 1224.5 B. t. u. per lb. Considerable moisture is contained in the exhaust steam because of condensation in the high pressure cylinder. On passing the orifice in the calorimeter and expanding to the condenser pressure this steam is superheated and the total heat content can then be calculated from the pressure and temperature readings. Piping from the high pressure exhaust line to the condenser should be as short and direct as possible. The calorimeter and vacuum gage connection can be made to the main exhaust line at any convenient point. Thermometer readings show 20 deg. superheat, the vacuum gage 25.9 in. of vacuum, and from the tables the heat content of the steam is determined as 1124.5 B. t. u. per lb. Subtracting the two values gives a heat extraction of 100 B. t. u. per lb. of steam and the water rate of the high pressure cylinder is $\frac{2545}{100}$ or 25.45 lb. per i.hp. hr. The total steam flow per hour through the engine is 452 × 25.45 or 11,503 lb. and the engine's water rate is $\frac{11503}{452 + 488}$ or 12.23 lb. per i.hp. hr.

CALORIMETER EXHAUSTS IN VACUUM SYSTEM TO OBTAIN LOW PRESSURE

The average receiver pressure in compound condensing engines does not exceed 12 lb. and the exhaust steam, expanding through the orifice in the calorimeter to atmospheric pressure, would produce no superheat. In fact the steam issuing from the calorimeter would be very wet and a calculation of its heat content could not be made. The steam must expand to a pressure low enough to produce a slight superheat temperature at the lower pressure which explains why the calorimeter is connected to the vacuum line. There are some cases where the steam from the calorimeter could discharge to the atmosphere, for instance, a non-condensing compound with a receiver pressure of at least 35 lb. This means a much higher water rate for the high pressure side. The heat content of the exhaust is higher and when expanded to atmosphere through the calorimeter, will usually be superheated.

The formula will apply to saturated steam conditions occasionally as, for instance, with single valve compound engines with a high water rate. In the case mentioned, with saturated steam at 145 lb. gage, H_1 is only 1194.5 lb. With 100 B. t. u. per lb. extracted in the high pressure cylinder, the exhaust at 12 lb. pressure has only 1094.5 B. t. u. per lb., less than the heat content of dry saturated steam at 25 in. vacuum, and no superheat would show on the low pressure side of the calorimeter. Single valve engines, however, have a water rate so high that not over 70 B. t. u. per lb. would be extracted in the high pressure cylinder and the exhaust would contain 1194.5 — 70 or 1124.5 B. t. u. per lb. Thus the formula will apply in saturated steam cases only where the water rate is high. The quality of the saturated steam entering the throttle must always be determined with the calorimeter. The steam rate of non-condensing auxiliary engines in a condensing steam plant can be found by connecting the calorimeter exhaust to the vacuum system.

RESEARCH ON the constitution of coal, cannel coal, boghead coal and oil shales is being continued by R. Thiessen, research chemist at the Pittsburgh, Pa., experiment station of the Bureau of Mines, Department of Commerce. The purpose of the investigation is to study the structural, chemical and physical composition of coals and bituminous shales. Such knowledge is of recognized importance in the coking, and recovery of by-products in coals; in the distillation of oil shales, and the recovery of their products; in the experimentation of liquefying coals, and in the most efficient utilization of the fuels. A detailed study of the origin of coals and bituminous shales is being continued. At present the study is being centered on how far the plant compounds were changed, and what compounds have remained unchanged during peat-forming and transformation into low-rank coals.

Worthington Builds New Diesel Engine

DEVELOPMENT OF A DOUBLE ACTING, TWO-CYCLE ENGINE MAKES POSSIBLE LIGHTER ENGINES WITH THE SAME POWER AND MATERIALLY REDUCES MAINTENANCE

EXAMINATION of the types of Diesel engines which have predominated both in the marine and stationary field reveals certain basic characteristics that admittedly have limited the extent of application.

Horsepower output of any engine depends primarily upon the diameter and stroke of the piston and upon the number of power strokes made per minute. The high pressure carried by the Diesel necessitates sturdy construction. In the single-acting four-cycle type only during

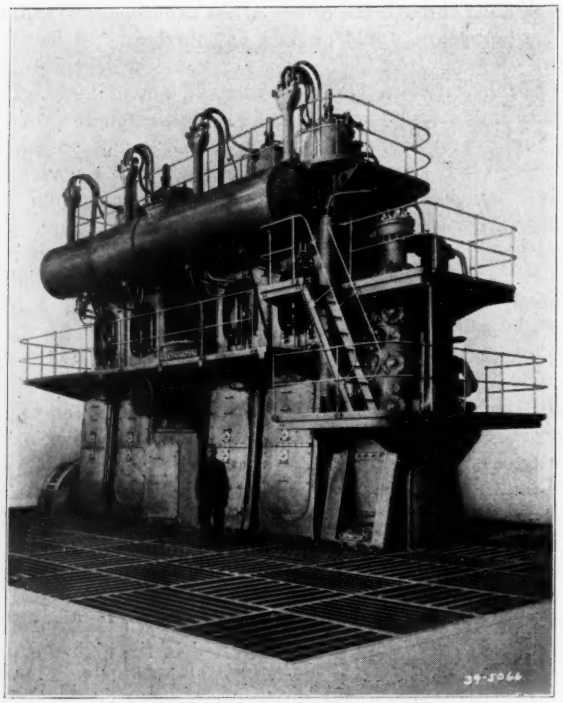


FIG. 1. WORTHINGTON 28 IN. BY 40 IN. FOUR-CYLINDER, TWO-CYCLE, DOUBLE-ACTING DIESEL ENGINE

one stroke in four does combustion and the generation of power occur. When considering power generation only, the engine parts have a use factor of but 25 per cent and the cost per horsepower must be high.

If, however, the engine is built to work on the two-cycle single-acting principle, a power stroke occurs once per revolution instead of once in two revolutions. If the same power be developed during each working stroke, it is obvious that the output has been doubled. This means that the weight of the engine per horsepower rating has decreased. Unfortunately this weight reduction is limited in the single-acting engine, for a scavenging-air pump must be incorporated in the design, thereby adding to the engine weight. The fact that in the two-cycle engine the exhaust port is uncovered by the piston when the latter has made but 80 per cent of its stroke reduces the output per power stroke. Furthermore the power required to drive the scavenging pump must be supplied by the engine, lessening the net shaft horsepower. To avoid these unalterable characteristics engineers of the Worthington Pump and Machinery Corp. turned their attention to the evolution of an engine of the double-acting two-cycle type wherein every stroke of the piston would be delivering power to the crankshaft.

DOUBLE-ACTING ENGINE BUILT FOR SHIPPING BOARD

Engines now being built for the U. S. Shipping Board and private interests have four cylinders 28-in. diameter by 40-in. stroke, and when operating at a speed of 95 r.p.m. have a rated output of 2900 brake horsepower delivered to the shaft coupling. One of these engines is shown in Fig. 1, while Fig. 2 is a cross section through the cylinder.

The double-acting principle is not exclusive to the Worthington Diesel but the latter possesses features of design whereby certain objectionable characteristics of the usual double-acting engine have been overcome.

One of the major items of Diesel maintenance is the matter of cylinder head renewal and repairs. During the combustion period the inner surface of the combustion

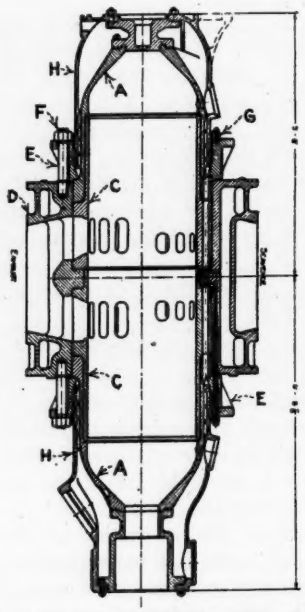


FIG. 2. CROSS SECTION THROUGH THE CYLINDER OF A WORTHINGTON DOUBLE-ACTING ENGINE

space is heated while the outer surface is kept cool by the jacket water. This condition sets up heat stresses that must be resisted by the structure of the combustion space wall. In addition there are stresses due to insufficient local cooling and excessive heating, but these are negligible compared to the more important heat stresses.

Heat absorbed by the walls is due principally to radiant heat and its amount depends upon the weight of fuel burnt per hour per unit of exposed wall surface. If comparison of the amount of heat absorbed per unit of combustion wall surface of various types of engines is to be made, it should be done on the basis of cylinders of the same speed and the same power.

By this method of comparison it may appear that the four-cycle engine suffers considerably less wall stresses than the single-acting two-cycle engine and somewhat less than the double-acting two-cycle. The time element, however, is important inasmuch as the duration of the heat transfer period influences the amount of heat transmitted to the walls per unit of time. If combustion occurs during 1/10 of the power stroke in a four-cycle engine, heat is flowing during only 1/40 of the cycle, which requires two revolutions to complete. On the other hand the double-acting two-cycle engine has four combustion periods per cycle or during 1/10 of the time. If 125 heat units are absorbed per hour, per unit of surface, the actual rate of heat transfer is 1250 units per hour, which when compared with the single-acting, four-cycle rate of 4000 gives the double-acting engine a ratio of 1250 to 4000.

If, as is claimed by many engineers, the actual rate of flow is the determinng factor in combustion chamber wall stress, obviously the double-acting engine has three times as much advantage. Of equal importance is the fact that for the same power output per cylinder the single-acting, four-cycle engine must have a cylinder volume practically four times that of the double-acting, two-cycle. This calls for thicker cylinder heads, which must endure greater heat stresses by reason of the increase in the metal thickness. It must be conceded that in the usual engine design these heat stresses cannot be ignored and are among the chief difficulties confronting the designer and user of oil engines. They will continue to set a size limitation as long as engineers adhere to this traditional design. It was these considerations that prompted the Worthington engineers to evolve a cylinder construction at once rational and surprisingly efficient, yet of the most simple design.

As shown in Fig. 2, each cylinder of the Worthington design is made up of two dome-shape working chambers, *A A* and a common central block *D* containing the exhaust and scavenging air ports.

It may be seen that the dome shape of the cylinder end is of a contour best adapted to withstand internal pressure. Into the steel cylinder is pressed a thin cast-iron liner *C* to take the wear occasioned by the movement of the piston, cast-iron being preferable to steel for a rubbing surface. This liner, however, is not called upon to withstand any radial pressure stresses all of which are carried by the surrounding steel cylinder body. The inner ends of both the upper and lower cylinder liners are enlarged to accommodate the exhaust and scavenging ports. The block *D* has an internal ring-shaped ledge or flange upon which the machined face of the inner liner ends rest. The liners, steel cylinders and block are all clamped into a single assembly by the circular lugs *E* and studs *F*, the lugs bearing against the formed inner ends of the steel cylinders. This construction permits outward expansion of the liners and shells without disturbing the central assembly.

To form a water-cooling jacket a light cast-iron cover *H* is slipped over the cylinder and is bolted at the outer end to the flange of the cylinder cover, while the inner end is packed against leakage by a light gland and fibrous packing ring. To intensify the cooling action the jacket surface of the steel cylinder is corrugated as shown in Fig. 3. The cooling is further increased by the introduction of the water through the central block. Flowing through the passages in the block, the water enters drilled holes in the inner ends of the liners. Retarders, consisting of steel rods in the holes increase the water velocity to about 3 ft. per sec. resulting in a high rate of heat transfer from the liner and steel cylinder.

Some engineers have raised the point that the joint between the liner and steel shell will increase the resistance to heat flow; calorimeter tests, however, indicate that the increase, if it exists, is of negligible value. After passing through the holes, shown in Fig. 3, the water flows along the space between the jacket cover and the steel cylinder, the amount being regulated by valves at the outlets in the cylinder ends.

Thirty Day Non-Stop Test Proves Reliability

That the cooling system is efficient in action as well as rational in design is proved by temperature readings taken

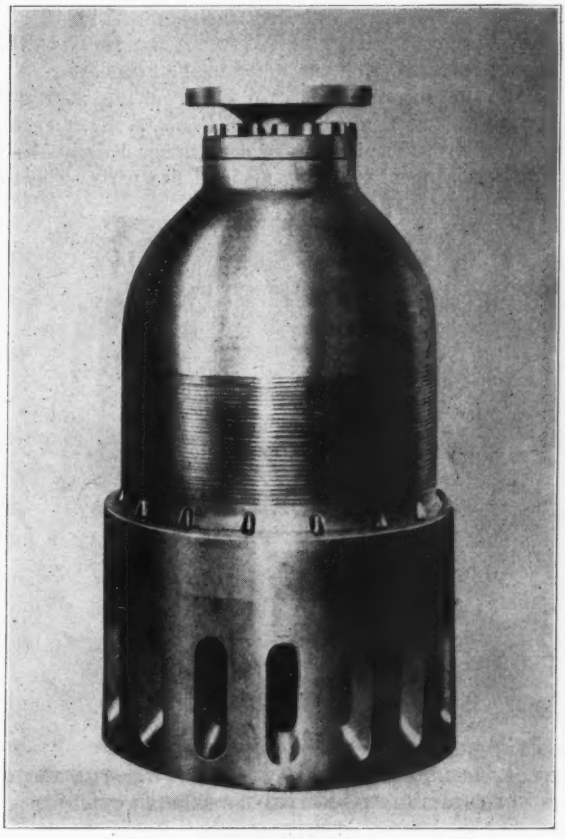


FIG. 3. CYLINDER AND LINER ASSEMBLY SHOWING EXHAUST PORTS

during a 30-day, non-stop test. This test was run on a one cylinder, 27 in. by 40 in. double-acting, two-cycle Diesel engine. It was conducted by Worthington engineers and observed by engineers of the U. S. Shipping Board. The location of the pyrometers are shown in Fig. 4. Attention is called to the readings taken on the jacket side of the combustion chamber and at a point about 1/100 in. beneath the inner or exposed surface. The temperature gradient through the metal is low, thus allowing only slight internal heat stresses. This phenomenon is traceable to the effective cooling water system and to the thin section made possible by the steel construction.

Additional data taken during the test are shown in

Table I. Observations at point near the outlet from the cylinder, showed an invisible exhaust at all times. The test demonstrated the reliability of this type of engine.

Duration of test, hr.	720
Total number of revolutions during test	3,879,921
Average speed, r.p.m.	89.8
Average brake load, lb.	2400
Length of brake arm, ft.	15
Average br.hp.	615
Average indicated m.e.p., top cylinder, lb.	81
Average indicated m.e.p., bottom end, lb.	77
Average indicated hp., top cylinder	420
Average indicated hp., bottom cylinder	359
Fuel oil consumption average of four 2 hr. tests, per br.hp. hr., lb.	0.428
Gravity of fuel, deg. Be.	28 to 32
Fuel oil consumption per i.hp. per hr., lb.	0.339
Mechanical efficiency measured during the four tests, per cent	79.5
Average lubricating oil consumed in the cylinder and piston rod stuffing box per 24 hr. gal.	4.03
Average exhaust temperature, deg. F.	510

In Fig. 6, the piston is of such unusual design as to merit special mention, being made of five parts. The two

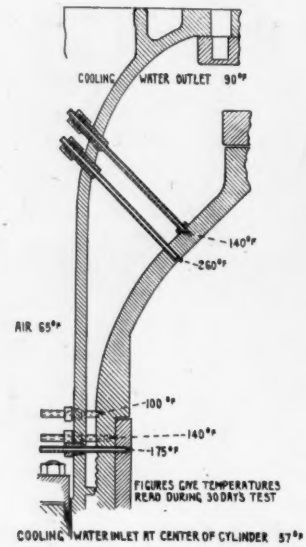


FIG. 4. DURING THE 30-DAY TEST THIS WAS THE METHOD OF LOCATING PYROMETERS FOR READING CYLINDER TEMPERATURES

end sections exposed to the heat of combustion are of alloy steel. Between these tops of crowns are placed the two cast-iron bodies holding the piston rings. These four parts are fastened to the piston rod and in the space between the two assemblies are clamped the two halves of a cylindrical central section which are held together by keyed bolts. The design has the advantage that the parts may be taken apart quickly for repairs or renewal and the piston is much lighter than a one-piece construction.

The piston rod is hollow and is provided with a central tube to convey the cooling water to the piston heads, the return being through the space between the tube and the walls of the drilled hole. The water reaches the rod by means of telescopic tubes leading to passages in the cross-head. The stuffing-boxes of these tubes are located outside of the crankcase enclosure, eliminating all danger of water mixing with lubricating oil.

Doubt has been voiced by some as to the practicability of piston rod packing rings. The stuffing-box and packing-ring design adopted has led to no operating trouble. Leakage along the rod has been eliminated, as shown by indicator diagrams taken at the three points

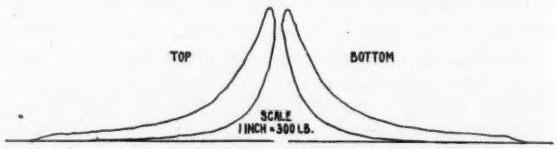


FIG. 5. TYPICAL INDICATOR CARDS TAKEN DURING THE TEST

along the stuffing-box reproduced in Fig. 7. The rings are cooled both by the heat transfer to the water flowing through the piston rod and by a liberal application of lubricating oil, the latter being recovered. Metallic packing rings have been brought to a high state of development through use for some 20 yr. in large double-acting gas engines. The piston rods in the largest machines built by Worthington are 15 in. in diameter, whereas on the largest size of Diesel engine the rod is approximately 9 in. Blast

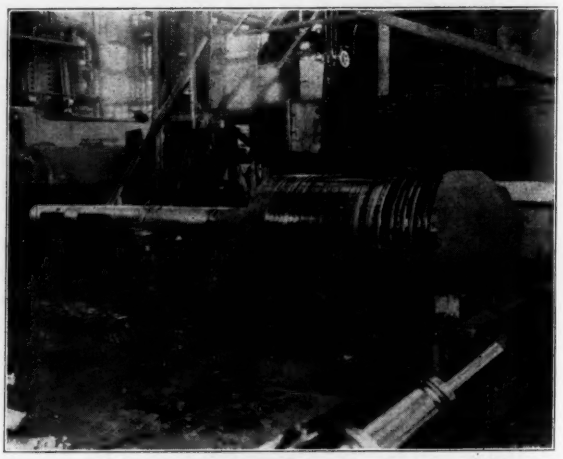


FIG. 6. AT THE END OF THE 30-DAY TEST, THE PISTON LOOKED LIKE THIS

furnace gas carries in suspension considerable grit making the problem more severe in the gas engine, yet the maintenance of packing rings in these machines is not excessive.

The fuel spray valves are of simple design, consisting of a body together with a needle valve and atomizing disk. Oil is introduced above the disks by the governor controlled pump and when the needle valve is raised by the cam and valve rocker, high pressure air forces this fuel into the cylinder in the form of a nebulous spray. The top fuel spray valve is located along the cylinder axis, resting in a forged cover plate which seals the opening in the top cylinder end and to which is also bolted the light outer cooling-jacket cover. The only part of the spray valve exposed to the heat of combustion is the tip which is a very small fraction of the area; the rest of the body is surrounded by the water-cooled cover.

Fuel is supplied to the lower combustion space by two spray valves. Due to the presence of the piston rod it is impossible to place the spray valves axially and therefore

they are placed in an inclined position. Each valve tip has two holes so placed that the oil does not strike the rod but passes on either side; there are then, 4 oil spray streams, which insure complete mixing of the oil and air.

Since the oil when introduced into the spray valve body would have a tendency to flow downward and away from the tip, unless some provision were made, only the injection air would enter the cylinder when the needle opens. To overcome this, the valve body is equipped with a sleeve into which the oil is introduced tangentially and the resulting turbulence holds the oil around the needle tip. The needle valves are actuated through a set of rockers and pull rods by cams placed on a camshaft running along the engine above the frame.

In Fig. 8 is shown the fuel pump, which consists of a steel body provided with a plunger for each engine cylinder end. Double discharge valves of the poppet type are incorporated in the design. For marine service the amount of fuel is controlled by a lever action which regulates the timing of the pump suction valves; an overspeed governor is also a part of the mechanism. For stationary service a standard governor is used.

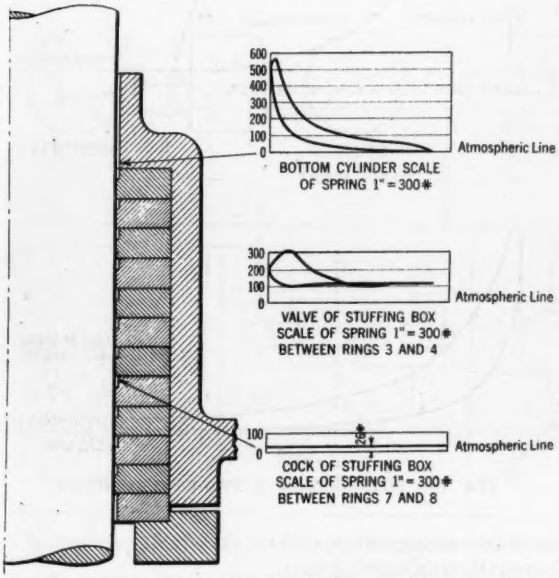


FIG. 7. THESE INDICATOR DIAGRAMS, TAKEN AT THREE POINTS ALONG THE STUFFING-BOX, SHOW HOW THE PACKING RINGS HAVE ELIMINATED LEAKAGE

As in all two-cycle engines a scavenging pump is a necessary part of the unit. After due study the reciprocating type of pump was adopted inasmuch as its power requirements are less than those of a turbo-blower. To reduce the diameter of the scavenging pump cylinders while avoiding a long stroke, the pump is made up of two double-acting cylinders placed in tandem. A constant pressure in the scavenging manifold being desirable, the pump is driven at twice engine speed. However the stroke is only 20 in. resulting in the same piston speed as the power cylinders. This reduces its bulk and weight. The pump handles 15,000 cu. ft. of air at low pressure. Automatic valves open only by reason of a difference in pressure between the top and bottom sides, the differential needed to lift a light weight valve being about 1 lb., which would reduce the pump efficiency under the existing conditions to less than 40 per cent. To avoid this power loss, mechanically operated valves are used, bringing the efficiency up to 75 per cent. The valves are of the rotating type and working under a low pressure are easily lubricated. The pump pistons are made of an aluminum alloy and have no rings, air leakage being negligible by reason of the slight pressure difference.

For an engine of this size the spray air compressor is a machine of large dimensions, absorbing considerable power, and it was considered justifiable to adopt more expensive but more rational crosshead running gear, following the same ideas as used in the main engine itself. The loss of the lubricating oil which always attends a trunk construction with a forced feed lubricated engine is thereby saved and the consequent carbonization of oil in the compressor avoided. The compressor has four stages, of which the first is double-acting; each stage discharges its air to a straight-tube cooler. In comparison with a three-stage compressor of the same capacity, it is calculated that the fourth stage reduces the temperature increase between the initial intake and the discharge into the after cooler by 23 per cent and the power consumption by 20 br.hp.

FIG. 8. FOR A WORTHINGTON FOUR-CYLINDER, DOUBLE-ACTING, TWO-CYCLE DIESEL ENGINE, A FUEL PUMP OF THIS TYPE IS USED

Thermal efficiency, that is, the percentage of the energy in the fuel oil converted into effective work, is as high as met with in the four-cycle single-acting engine. The fact that the exhaust port is uncovered when the piston has about 10 per cent of its stroke to complete together with the belief that the clearing of the cylinder of the burnt gases by scavenging is faulty, is the basis of the common idea that the power per cubic foot of piston displacement and the efficiency are less with the two-cycle type. That this is erroneous has been demonstrated by

tests. It is true that for a given consumption of fuel the early release of gases through the exhaust ports causes a decrease in the indicated horsepower; however, it is net or shaft horsepower that the user is interested in and this in the double-acting two-cycle is equal, if not superior, to that of the four-cycle single-acting type. The reason is found in the fact that during the four-cycle suction and exhaust strokes, power is consumed in overcoming friction.

Mention should be made of the relative abilities of the four-cycle and two-cycle double-acting engine to generate power efficiently. As usually viewed, the plan of scavenging the two-cycle engine by means of air introduced through ports, fails to remove all of the burnt gases. For this reason, so some have claimed, part of the inert gases are retained in the cylinder. Furthermore the piston does not cover the exhaust ports until 10 per cent of the return stroke has been made. These factors are assumed to limit the power developed per unit of piston displacements.

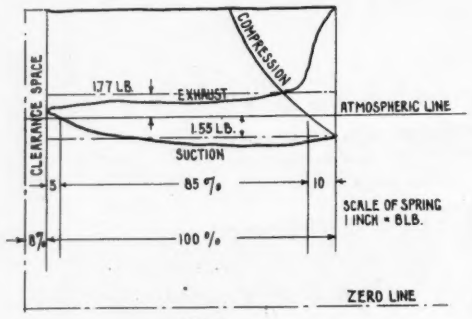


FIG. 9

FIG. 9. THIS IS A LIGHT SPRING INDICATOR CARD FROM A FOUR-CYCLE ENGINE

This statement is far from representing actual engine conditions.

Scavenging Requires Little Power

In Fig. 9 is shown a light-spring indicator diagram from a four-cycle engine. It will be noticed that the cylinder pressure drops below atmosphere during the exhaust and suction strokes. At the beginning of compression the pressure is still sub-atmospheric and, as a consequence, the weight of the air trapped within the cylinder is less than would be the case if the charge were at atmospheric pressure. Furthermore, the clearance space remains filled with burnt gases at a slight over pressure when the exhaust stroke is completed, and these, re-expanding on the suction stroke, reduce the volumetric efficiency. These conditions limit the amount of pure air charge to approximately 90 per cent of the piston displacement plus the clearance volume with an oxygen content but 96 per cent of that which would be obtained by 100 per cent scavenging.

In Fig. 10 is shown a light-spring indicator diagram of the two-cycle cylinder. The greater part of the burnt gases passes through the exhaust ports by virtue of its own kinetic energy and therefore requires no scavenging air. The latter has much less work to do than is commonly assumed, the air volume being about twice the cylinder volume and weighing some six times as much as the spent gases to be scavenged from the cylinder. The fresh air trapped in the cylinder when the piston covers the exhaust ports has almost 93 per cent of the oxygen it would contain if the scavenging action had been 100 per cent.

Inasmuch as the power consumed by the scavenging pump is less than 4 per cent of the engine's output, and the power lost by early exhaust is about 5 per cent, it requires no argument to prove that the net power per unit of piston displacement obtained in the double-acting two-cycle engine is equal to that of the four-cycle.

On the basis of net thermal efficiency the two engines are about equal. As previously noted the advantage of the double-acting engine lies in its decreased weight and more compact design. It should be noted that the weight of the double-acting two-cycle Worthington engine is only 61 per cent of the single-acting four-cycle engines, and, if the former's piston speed be raised to that of the latter,

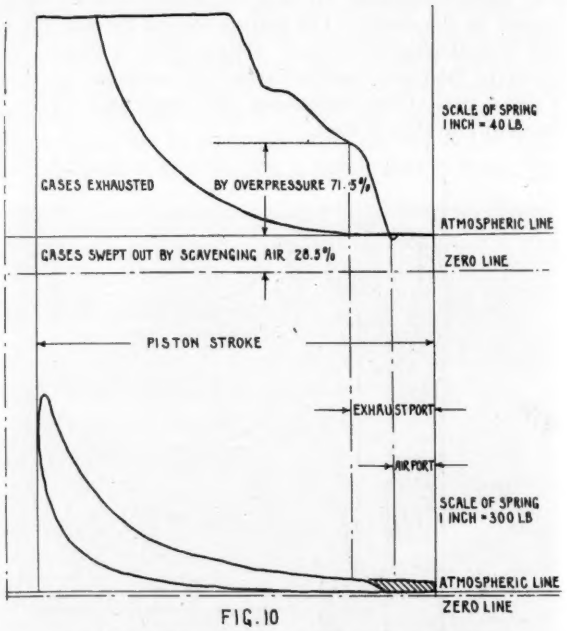


FIG. 10

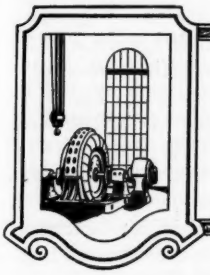
FIG. 10. THIS IS FROM A TWO-CYCLE ENGINE

the double-acting unit would weigh only 44 per cent of the four-cycle, single-acting unit.

Of equal value is the simplicity of valve gearing. With all exhaust and admission valves with their attendant cams, push rods, rocker arms, springs and cages eliminated, 90 per cent of the maintenance of the engine is avoided. This reduces not only the cost of parts but, of greater importance, eliminates a maintenance crew.

At present the design is confined to two sizes, the cylinders being 28 by 40 in., and 16 by 24 in., respectively. The latter is rated at 250 br.hp. per cylinder at 180 r.p.m. Another line of 34-in. bore by 48-in. stroke is contemplated which, at 110 r.p.m., will develop 1500 br.hp. per cylinder. This means that single-crew motorships of as high as 12,000 br.hp. are feasible, bringing about a further simplification, which should be reflected in the crew wages and repair cost.

Globe or gate valves should never be placed in the discharge line of a compressor between the machine and receiver unless a pop safety valve of sufficient area is installed on the compressor side.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Transformer Connections---V*

METHODS OF ANALYZING VOLTAGE RELATIONS IN, AND METHODS OF PARALLELING, 3-PHASE BANKS. BY V. E. JOHNSON

IN CONSIDERING a single phase transformer as a unit, it is evident that there can be but two relations between the primary and secondary voltages, for if these are not "in phase" they necessarily must be in opposition. If they are to be connected in parallel, other characteristics being correct, the secondary leads of the two units must be joined "straight" or they must be joined "crossed," as no other possibilities exist.

When the three units have been joined into a three phase group, or when the three windings of a three phase transformer have been so connected, information as to the polarity of the individual transformers is not sufficient, and consideration must be given to the characteristic known as "phase rotation."

Figure 1 shows a three phase generator connected to a three phase transformer, which in turn is supplying a three phase induction motor. For simplicity it is assumed that the ratio of the transformer is 1/1. With the rotation indicated on the generator, the field will set up a phase rotation which can be described by saying it has the sequence G1, G2, G3. It is evident that this designation does not mean anything in itself, for if the leads were crossed, or if they were lettered differently, the same machine would have a sequence of say G2, G1, G3. On the other hand, if the marking of the leads were unchanged, and the rotation of the rotor reversed, the phase sequence would be reversed.

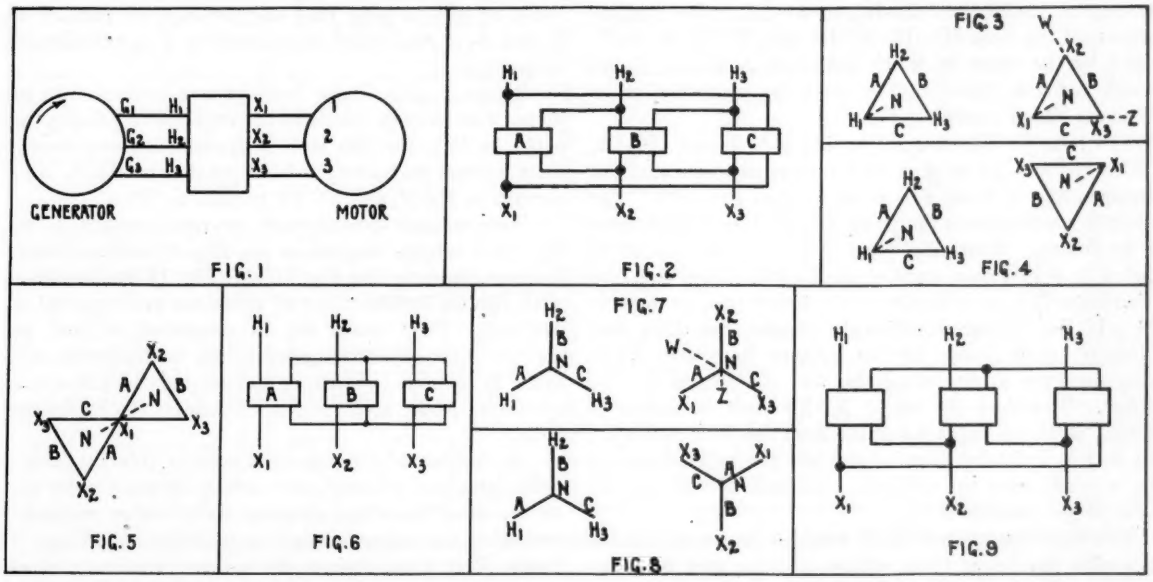


FIG. 1-9. TRANSFORMER CONNECTIONS FOR 3-PHASE BANKS WITH CORRESPONDING VECTOR RELATIONS

With connections made as shown, it follows that when the generator leads have a G1, G2, G3 sequence, the primary side of the transformer will have a H1, H2, H3 sequence. If the Power Club rules[1] are followed in lettering the transformer leads, the secondary will have a rotation of X1, X2, X3, and the motor would therefore run in the same direction whether its leads 1, 2 and 3 were connected respectively to H1, H2, H3 or to X1, X2 and X3.

In paralleling alternators having equal voltages and frequencies, it is necessary in making the first connection to determine that they have the same phase rotation, and this having been determined, the synchronizing apparatus is connected. Similarly in paralleling two three-phase banks or units, it is necessary to have the same

*Preceding articles of this series appeared in the following issues of Power Plant Engineering: Sept. 15, 1925; Nov. 1, 1925; Dec. 1, 1925, and February 15, 1926.

[1]Note: Rule 10 reference No. 5406 provides that "the markings shall be so applied that if the phase sequence of voltage on the high voltage side is in the time order of H1, H2, H3, it is in the order X1, X2, X3 on the low voltage side and Y1, Y2, Y3 for a tertiary winding."

voltage and frequency, the same phase rotation, and finally, the same phase displacement between primaries and secondaries on the banks under consideration. In other words the secondary voltages must be in step when the primaries are fed from the same busses.

Graphical Representation of Voltages

Because of the somewhat complicated relations existing between the primary and secondary voltages in a three-phase bank or unit, proper connections between the units, and between the different banks requires a clear conception of the vectors involved, and thus necessitates the use of some method of graphical representation. As the actual values of the voltages is not involved in this portion of the analysis, it is sufficient to represent them by straight lines of convenient length, joined at angles which correspond to their electrical phase relations.

Figure 2 shows three single phase units connected in delta-delta, with voltage relations as in Fig. 3. The line H1-H2 is parallel to X1-X2—these representing the high and low voltages of transformer A. Similarly H2-H3 is parallel to X2-X3, and H3-H1 to X3-X1. The relative position of the lines H1-H2, H2-H3 and H3-H1 is determined by the order in which the units A B and C are placed, but they must in any event be connected so as to form a closed triangle.

The triangle H1, H2, H3 having been drawn, X1-X2, X2-X3 and X3-X1 must be so arranged as to parallel the corresponding H lines, and so as to close the delta. For example, starting from the point X1, the line X1-X2 must be as shown. From the point X2, the line X2-X3 is started in a direction parallel to H2-H3. This could be either towards w as indicated by the dotted line, or towards X3. If the former direction be chosen, the delta can evidently not be closed, for the distance from w to X1 is more than the available voltage, and the angles are incorrect. Therefore the vector X2-X3 must be drawn as shown. With the point X3 as the start for the line X3-X1 this may be extended towards z as per the dotted line, but this will not close the triangle, so it follows that X3-X1 is the proper location for it.

The lines designated H1-N and X1-N are in accordance with the Power Club rulings, and are used to designate the phase position of the triangles. In this particular case these lines are in the same direction, indicating zero phase displacement. Furthermore since the terminal points H1 and X1 are adjacent, the polarity is subtractive.

If the units had additive polarity the voltage diagram would be as in Fig. 4, where X3-X1 parallels H1-H3, X1-X2 parallels H2-H1 and X3-X2 parallels H2-H3. The dotted lines H1-N and X1-N indicate a phase displacement of 180 deg.

Figures 3 and 4 have the same phase rotation, namely H1, H2, H3 but different polarities. It is evident that a bank or unit connected as in Fig. 3 can not be multipled with one as in Fig. 4. If the primaries had similarly marked leads joined, and the two corners marked X1 were superimposed as in Fig. 5 the other corners will not coincide, nor can this condition be remedied by any change in the external leads.

Considering the individual units which compose the bank, for example "A" in Fig. 3 and Fig. 4, it will be noted that any attempt to parallel them by joining similarly marked leads would short circuit the secondaries through each other. Only by reversing the secondary leads of one bank inside of the delta can the two diagrams be made to coincide, so as to permit multiple operation.

Figure 6 shows three single phase units connected in star-star with voltage relations as indicated in Fig. 7, for subtractive polarity. The high side star having been made as shown, the low side is constructed by drawing X1-N parallel to H1-N, and from this neutral point extending the lines N-X2 and N-X3. As in the delta diagram, the line N-X3 could have been constructed in the direction w as per the dotted line, and N-X2 in the direction z but this would have produced an unsymmetrical diagram.

With additive polarity and the same external connections, a diagram such as that in Fig. 8 would result.

The phase rotations of Fig. 8 and Fig. 7 are the same, but there is an angular phase displacement of 180 deg. No change in external leads can convert one into the other, and the two banks could not be paralleled. Fig. 8 can, however, be changed into Fig. 7 by reversing each low voltage winding so that the leads which now go to the neutral point become the line terminals.

Considering the individual units which compose the bank, it will be seen that any attempt to parallel Fig. 7 and 8 is equivalent to connecting the secondaries in opposition.

Figure 9 shows three transformers connected in star-delta, with voltage relations for subtractive polarity indicated in Fig. 10. The star is drawn as shown, and the delta formed by making X1-X2 parallel to H1-N, X2-X3 parallel to H2-N, and X3-X1 parallel to H3-N.

With additive polarity and external connections as in Fig. 11 a voltage diagram as per Fig. 12 will be obtained. Voltage diagrams like Fig. 10 and Fig. 12 can be obtained with various combinations of polarities and external connections. They could not be paralleled without some change in the lead arrangement, but the diagrams can be made to coincide by suitably rearranging the primary and secondary leads, and without disturbing the interconnections.

In this respect the star-delta bank is different from the delta-delta and star-star, for neither of these latter could be converted from one diagram to the other without rearranging the connections of the individual windings. The Power Club rules express the various relations that exist for the three general types of connections in a tabulation such as that in Fig. 13. A bank or unit in a given group may be paralleled with any other unit in the same group by properly arranging the external leads. Units in different groups can not be paralleled unless the internal connections can be changed to make them coincide. Groups I and II can be rearranged in this manner, but they can not be made to work with Group III. That is to say, a delta-delta bank can be made to operate with a star-star bank, but neither of these will multiple with a star-delta bank due to the inherent angular displacement.

It is not to be assumed from the foregoing that the typical voltage diagrams can be obtained only from the connections which have been given. As already indicated, any of the diagrams can be obtained from either additive or subtractive units, by properly interconnecting them.

The foregoing portion of this article has constantly referred to "three-phase banks or units" in an effort to treat these two classes of apparatus simultaneously. As a matter of fact, a three-phase transformer is virtually three single-phase units connected in one of the various ways outlined, and having an iron circuit of which certain parts are made

common. The three copper circuits are distinct, while the iron for the three is "blended" so to speak, in order to effect economy in material.

Three phase transformers are somewhat more difficult to connect than are the three unit groups, for the reason that the internal connections are not readily accessible. For that reason the name plates are provided with markings to indicate coil arrangement, voltage diagrams, polarity, and terminal arrangement. This is sufficient, in combination with the data on ratio and impedance, to decide upon the possibility of parallel operation, and to select the proper leads.

Installation Tests

If the connection to be made is that between two or more units or groups located adjacent to one another, and all having proper and legible terminal markings, the matter is quite simple. If, on the other hand, a new unit is to be added to an existing installation in which the leads are concealed in conduit so that they can not be traced out, or if the location is sufficiently distant from the existing installation to make the proper selection of conductors by inspection impossible, then dependence must be placed on tests. While the methods outlined are applied specifically to three-phase units, they could be applied as well to single-phase transformers banked, with the difference that in the latter case considerably more information could be obtained by checking the leads visually. Furthermore in the absence of name plate data, polarity tests on simple phase units are comparatively simple, while obtaining diagrams on three phasers is quite difficult, particularly with a high ratio of transformation.

It is assumed that the ratio of transformation and impedance of the new unit is correct, and that the connection falls in groups that can be paralleled. If the latter requirement is not met, it will be impossible to obtain a set of diagrams which will coincide, nor can the terminal voltage across the switches to be closed be made zero.

Delta-delta Units

Assume that a delta-delta unit is to be connected between the high and low busses as in Fig. 14, and that it has been impossible to properly phase out the existing conductors. The high tension side would usually be connected at random, the position of the leads being largely a matter of safe clearances.

Ordinarily it would be safe to close one of the single pole disconnecting switches between unit No. 2 and the bus, but it would be advisable to first test between the terminals, as from X1 to A to determine that there were no accidental connections. This test having been made, X1 should be joined to A, either by closing the disconnect or by using a suitable fuse of small capacity. Measurements of voltage should then be made between all of the terminals, and the values plotted to a suitable scale as outlined below. Refer to Fig. 15.

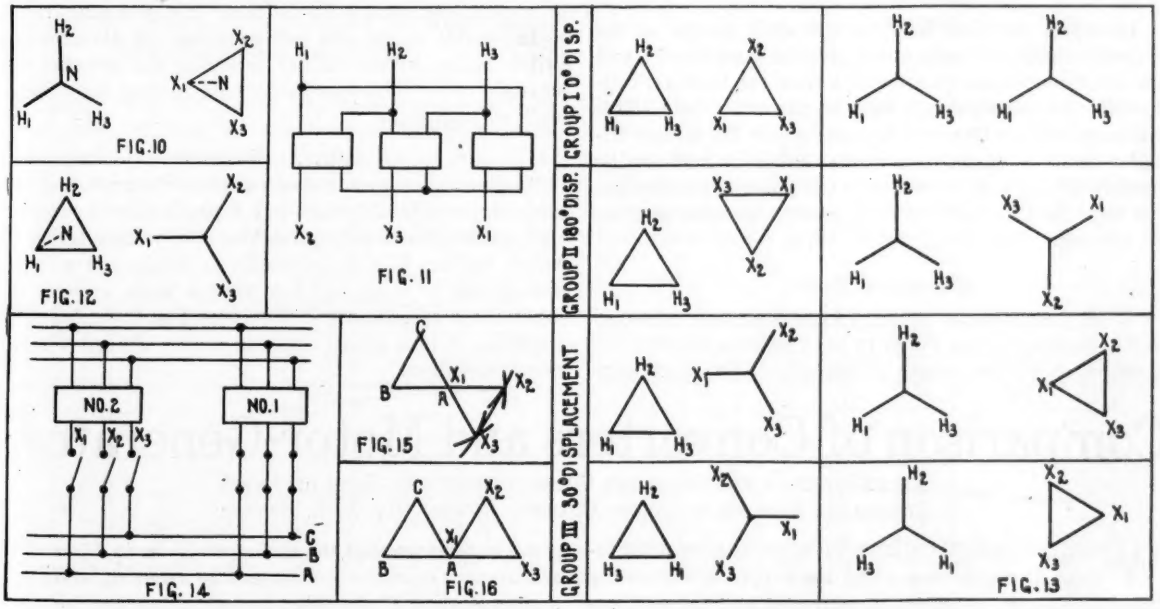


FIG. 10-16. DIAGRAMS USED IN ANALYZING THE VOLTAGE RELATIONS OF 3-PHASE TRANSFORMER CONNECTIONS

The voltage AB, BC and CA would be equal to 100 per cent low side voltage, and could be plotted into a triangle with sides having the length 100. Similarly the voltages X1-X2, X2-X3, and X3-X1 would be 100 per cent secondary and would therefore be plotted to the same lengths as the sides of the triangle ABC. Measurements from one side of the disconnecting switches to the other would give zero, 100 per cent, 173 per cent or 200 per cent depending on the phase relations, and with the values so obtained the voltage diagram would be constructed as follows:

Draw the voltage triangle ABC with 100 as the side. This would be the diagram for the existing installation. The new unit would have a similar triangle, but it could occupy a variety of positions, in any one of which the points A and X1 must coincide because they are connected. Using B as a center, draw an arc using the reading B-X2 as a radius. Intersect this with another arc using C as center and C-X2 as a radius. This point of intersection locates the point X2. In a similar manner arcs from B and C with radii B-X3 and C-X3 will intersect at the apex X3.

The triangle of the incoming unit is thus located with its relation to ABC.

Unless the two diagrams coincide the connection can not be made. If they do coincide, B-X2 and C-X3 will be zero. If the triangles obtained were arranged as in Fig. 15, no external rearrangement of leads would remedy the matter, and each leg of the delta would have to be reversed separately, this being equivalent to swinging the right hand triangle through 180 deg. with A as a center.

If a figure as in Fig. 16 were obtained, a change in the external leads would suffice, for these two triangles are in similar positions with their sides parallel. They would coincide by merely moving the right hand figure to the left a distance equal to the length of one side. In other words, by making B common with X1 the voltages would coincide.

Star-star Units

Inasmuch as these fall into the same groups as the delta-delta units, the tests would give the same results, and it would be impossible to determine from the terminal voltages whether the windings were in star or in delta. This is immaterial, for being in the same group the voltage triangles could be made to coincide, either by rearranging the external leads or by reversing the internal connections. The methods to be followed are exactly the same as those for the delta-delta.

Star-delta Units

If the transformers in Fig. 14 had been star connected on the high side, this would in no wise have affected the construction of the secondary triangles. Had they coincided, the switches could have been closed. If a diagram as in Fig. 16 had been obtained, a similar procedure would have permitted paralleling. If the diagram in Fig. 15 had been obtained, the phase relations could be corrected by reversing the secondaries inside of the delta, by reversing the star leads internally, or finally by rearranging the external leads on both sides as already discussed. The actual method would be to cross a pair of the star connected leads, and then repeat the tests until the proper relations were obtained.

The latter method involves no internal changes, and is generally to be preferred, but sometimes due to difficulties in maintaining safe clearance in the external leads one of the other methods must be used.

In units for three-phase four-wire systems, the neutral is connected first, after which tests are made in a manner analogous to that previously described. If the units to be paralleled have different-phase displacements, it will be impossible to get zero voltage across the disconnecting switch blades without either reversing the internal connections, or in delta star banks reconnecting the external leads on both sides.

Practical Methods

Ordinarily a lineman does not go to the trouble of constructing voltage diagrams, but depends upon a "cut and try" system, that finally gives him zero voltage across the switch blades. If it is impossible to obtain this with any combination of high and low voltage leads, or with any internal rearrangements it is evident that the existing installation is in a group that can not be worked with the new installation.

Comparison of Converters and Motor-Generators*

An Analysis of the Inherent Characteristics of Each of These Customary Sources of Direct Current Power. By W. B. Snyder

WHERE DIRECT-CURRENT power is needed for industrial requirements and the supply is alternating current, both the synchronous converter and the synchronous motor-generator set are well adapted for the purpose, since each possesses large momentary overload capacity, is thoroughly reliable, and is easily controlled either by hand or automatic means. Obviously, however, neither of these two types of machines is more serviceable than the other under all conditions, so there frequently arises the need for comparative information as to the inherent advantages of each type in order that the one which will be better adapted to a certain installation may be selected. The factors involved in the choice are:

First Cost and Efficiency
Power-factor
Power Contract
Power Supply
Direct-current Load

First Cost and Efficiency

The first cost of a synchronous converter with its accessory equipment is about 10 per cent less than the first cost of a motor-generator set with its corresponding equipment; and the efficiency of the synchronous converter is from 5 to 7 per cent higher than that of the motor-generator. Other things being equal, these two factors alone are of such great importance that the choice would be in favor of the synchronous converter. This may be reversed, however, by a consideration of the other factors.

Power-factor

The synchronous converter, as usually designed for industrial service, operates at approximately unity power-factor over a range from full load to ¾ load. As the load is further reduced, however, the power-factor is lowered very rapidly, being around 95 per cent lagging at ½ load, 55 per cent lagging at ¼ load, and 20 per cent lagging at no load. The converter therefore cannot be depended upon to improve the power-factor materially, although at ½ load and above the power-factor is very good.

In the case of synchronous motor-generator sets, the full-load power-factor may be unity, 85 per cent leading, or 80 per cent leading, depending upon the motor used. Sets for industrial service are usually equipped with 85 per cent power-factor motors. Unlike the synchronous converter, a synchronous motor will operate at a better power-factor at light load than at full load. Thus, a motor operating at 85 per cent leading power-factor at full load will run at 55 per cent leading power-factor at ½ load, 33 per cent leading at ¼ load, and 15 per cent at no load, provided the field excitation is unchanged. The motor-generator set thus possesses inherent characteristics which improve the power-factor of the total plant load.

*Reprinted, by special permission, from the General Electric Review.

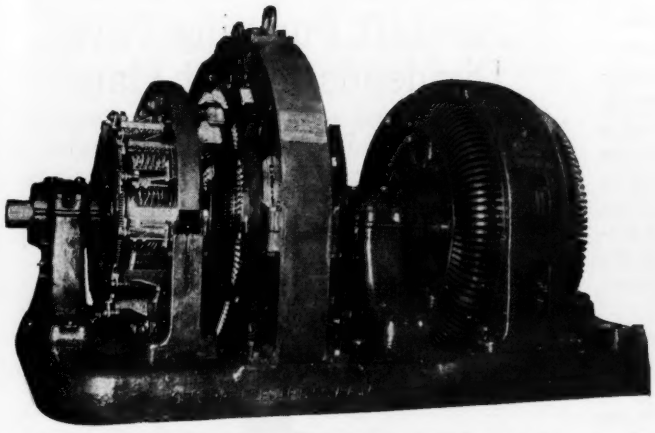


FIG. 1. A TYPICAL MOTOR-GENERATOR SET; THE GENERATOR RATED 1500 KW., 514 R.P.M., 250 V. AND THE MOTOR RATED 2100 KV.A., 514 R.P.M., 2300 V.

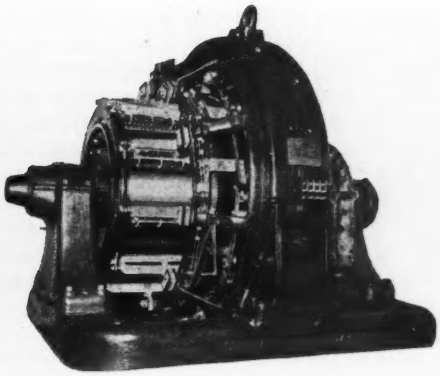
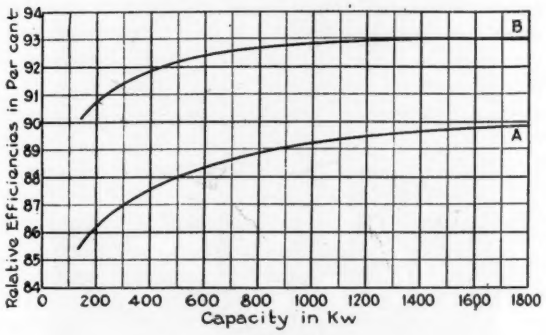


FIG. 2. A TYPICAL SYNCHRONOUS CONVERTER, RATED 2250 KW., 300 R.P.M., 250 V.

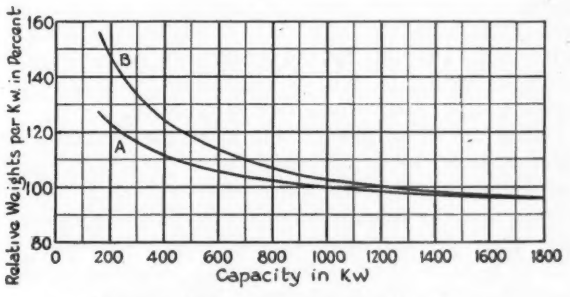
Looking at the question of machine power-factor from another point of view, the synchronous converter at no load draws from the line approximately 27 per cent of its rating in lagging kilovolt-amperes, this value decreasing to approximately 12 per cent at full load; while the 85 per cent power-factor synchronous motor will deliver to the line approximately 70 per cent of its rating in leading kilovolt-amperes at no load, this value decreasing to 52½ per cent at full load.

Power contracts vary considerably. Most of them have a demand charge and an energy charge, in addition to which some have a power-factor clause that requires the



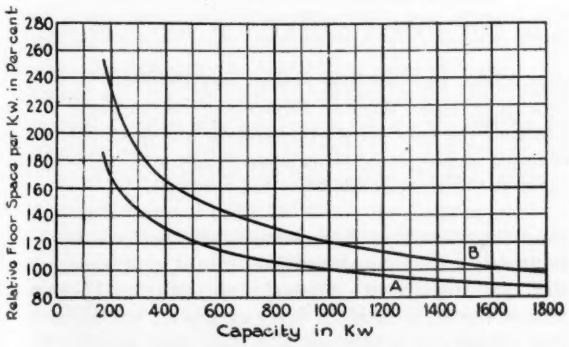
Curves of Efficiency

A: Motor-generator Sets
B: Synchronous Converters with Transformers. The losses included are those of the converter, transformer, and alternating-current bus between the converter and transformers



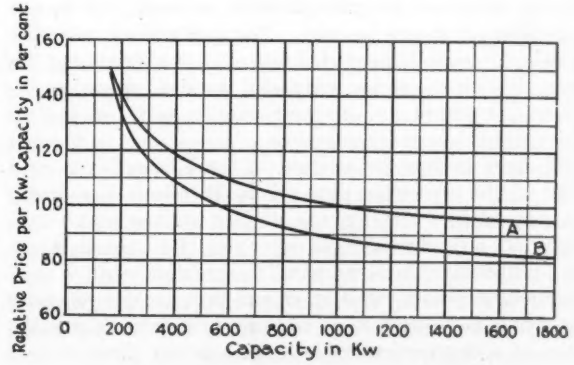
Curves of Weight Per Kilowatt of Capacity

A: Motor-generator Sets
B: Synchronous Converters and Transformers



Curves of Floor Space Per Kilowatt of Capacity

A: Motor-generator Sets
B: Synchronous Converters and Transformers



Curves of Price Per Kilowatt of Capacity

A: Motor-generator Sets with Complete Switchboard
B: Synchronous Converters with Transformers, Complete Switchboard, and Alternating-current Bus Material Between Converter and Transformers

FIG. 3. MOTOR-GENERATOR SETS AND SYNCHRONOUS CONVERTERS WITH TRANSFORMERS COMPARED WITH RESPECT TO EFFICIENCY, WEIGHT, FLOOR SPACE, AND PRICE PER KILOWATT OF CAPACITY

customer to pay a higher price when the average power-factor is below a stated value. Insofar as the demand and energy charges are concerned, the synchronous converter has a clear advantage of 5 to 7 per cent because of its higher overall efficiency. If the contract contains a power-factor clause, a careful determination should be made as to what the power-factor of the total load would be with the converter and with the motor-generator set. There are cases where improved power-factor will produce a saving in the power bill more than sufficient to offset the higher combined demand and energy charges of the motor-generator set, and if this factor be the ruling one it would justify the additional expenditure for the motor-generator set.

Power Supply

The ratio of the direct-current delivery voltage to the alternating-current supply voltage is more or less fixed in the case of the converter, but is not in the case of the motor-generator set. A limit is thus placed on the possible variation of the direct-current voltage of the converter, by changing its field excitation, in order to overcome variations in the alternating-current supply voltage. If, for example, the direct-current voltage of a synchronous converter is increased 10 per cent by changing the field setting, the heating of certain armature bars will be as much as three or four times normal. It is evident, therefore, that if the regulation of the alternating-current voltage supply is beyond that permitted on the direct-current system, a synchronous converter should not be used. If, on the other hand, the variation in supply voltage is within the limits allowable for the synchronous converter this equipment should be entirely satisfactory, at least with respect to the direct-current voltage delivered.

Since the direct-current voltage of the synchronous motor-generator set is independent of the alternating-current voltage supply, the motor-generator set is better adapted than the synchronous converter for those installations where the alternating-current voltage regulation is such as to cause direct-current voltage variations beyond those allowable in the direct-current load circuits.

Direct-current Load

If the nature of the direct-current load is such that over-compounding, frequent adjustment of voltage, or parallel operation with other motor-generator sets or engine-driven direct-current generators is required, the motor-generator set should be used. The synchronous converter may be successfully paralleled with other converters, but it is very difficult to secure successful parallel operation between converters and motor-generator sets, or engine-driven direct-current generators. This is due to the fact that every voltage disturbance on the alternating-current side of the converter proportionately affects the direct-current voltage. In any case, the best practice would indicate that a synchronous converter should be chosen where the proposition involves parallel operation with a synchronous converter installation, and that a motor-generator set should be selected as an addition to a previous installation of motor-generators or engine-driven direct-current generators.

Other Considerations

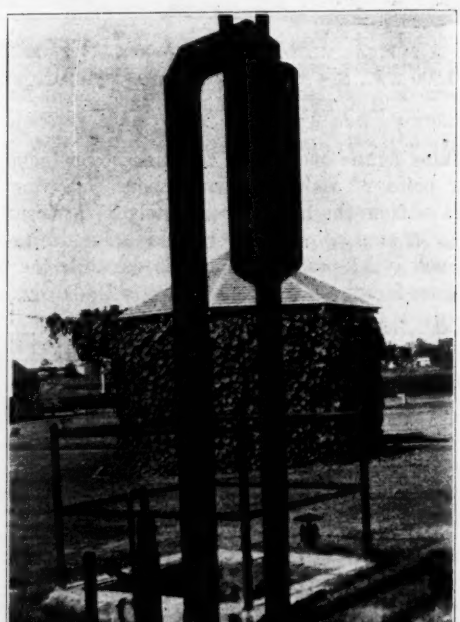
The motor-generator set has a slight advantage over the synchronous converter with respect to floor space, while for light weight of individual parts, ease in lining up and replacing armatures, the advantage is with the converter.

Air-Lift Pumping Pays Dividends for Oil Plant

Air-Lift Pumping System Used for Circulating Cooling Water. By Dudley W. Moore

AN INTERESTING water circulation system at the Prairie Pipe Line Co. pump station at Drunright, Okla., utilizes the air-lift principle in a homemade apparatus of novel design.

Old scrap pipe, ranging from 3-in. to 12-in. casing, together with a few valves and fittings, comprise the equipment. By welding this pipe together, sinking one end of it 20 ft. in the ground and utilizing a hot water sump, an



AIR LIFT PUMPING EQUIPMENT AT DRUNRIGHT, OKLA.

inexpensive but practical system was devised. It was designed by Sam Monroe, formerly chief engineer of the Prairie Pipe Line Co. at this station and is an interesting example of how some oil companies are making scrap material pay dividends for practical purposes.

This method was conceived when it was found by company engineers that the reservoir was too high for water to flow directly from the engines into it, and a more practical and inexpensive method was desired. The use of pumps was eliminated in favor of the air-lift method for this reason.

In connecting up the equipment a piece of 12-in. pipe, 20 ft. long is used, extending into the ground with the top level with the surface, in which an 8-in. pipe of the same length is inserted within 2 inches of the bottom. At the ground level a piece of 4-in. pipe is welded on to the 8-in. and extends to a height of 7 ft., at which point two

elbows connect it to a funnel of short 8-in. pipe provided with two air vents. At the base of the funnel a 3-in. pipe is welded and continues to the ground and then underneath about a foot where connection is made to a line which runs to the reservoir about 300 yd. away.

Running from the compressors on the Diesel engines to a connection alongside the surface pipe installation, a small air line is installed inside the 8-in. pipe (which is inside the 12-in.) and reaches within 2 ft. of the bottom. Two valves above ground, one of which controls the air from the compressors to the air line and the other the water from the engines to the sump, completes the equipment.

The air-lift principle of immersing the air one and a half times as deep as the height wanted to lift, is followed in this installation and the water, after coming from the engines, is raised to a height sufficient to flow into the reservoir by gravity where it is cooled and re-run. The use of excess air from the compressors, which is always present but seldom used, eliminates any lost energy as well as serving a practical purpose with no increase in expense.

Operation of this apparatus is simple. The hot water comes from the engines through an 8-in. line to the sump, (4x4 ft. and 3 ft. deep) and from the sump falls into the 12-in. pipe. Air is then forced through the 8-in. pipe which is inside the 12-in., and the air and water mixture forces the water upward through this pipe into the connecting 4-in. line above ground and thence into the funnel on the other side of the elbow, where the air vents let the air out and the water flows back by gravity from the funnel to the reservoir through the 3-in. line.

By this means of water circulation for cooling engines, the plant efficiency of this pipeline station has been substantially increased at practically no cost. The scrap material of which the apparatus is constructed is more or less regarded as junk and the air necessary to utilize for the operation of the equipment is obtained at no extra effort or expense, simply by allowing the compressors to blow off excess air. Water is always available and the operation of the system is therefore automatic in itself and requires no attention.

As the company maintains its own welding outfit, all joints in the water lifting apparatus are welded to insure uniformity and absence of leakage. The scrap pipe and other material going into the construction were scraped and painted with rustproof paint before being put together. The idea of reclamation and salvage of oil field material for many odd and important jobs around the station was given much thought and by adopting these methods, the company has saved large sums of money.

Pumps are used by most oil companies for their water circulating systems and the use of the air-lift method in conjunction with a cistern or sump is as interesting as the use of scrap equipment in the building of the apparatus.

PLANS HAVE BEEN approved by the county authorities for the highest earth dam in Massachusetts to be built for the New England Power Co. on the Deerfield River a-mile north of Monroe Bridge, near Greenfield, Mass. The dam will be 700 ft. high and will be located in Monroe and Rowe, Mass. It will be 25 ft. in width at the top and will extend in a straight line across the valley. The reservoir formed will be 2½ mi. long, will have a maximum depth of 84 ft. and will cover approximately 250 acres. Original plans were remodeled to meet approval of the county authorities.

Progress of Pit No. 4

BY FREDERICK S. MYRTLE

THE PACIFIC Gas & Electric Company's Departments of Engineering and Electrical Construction are now hard at work on Pit No. 4, the outstanding engineering features of which are similar to those of its immediate predecessor, Pit No. 3, which was formally placed in service August 1, 1925. They include a diversion dam, by which the waters of the stream will be impounded into a reservoir reaching back to the development nearest upstream and thus forming an open conduit for the water released therefrom, to the entrance of a tunnel by which water diverted at the dam will be conveyed in a bee-line across country to a point from which it will be dropped to turn the wheels of a powerhouse on the river bank below.

Location for the dam has been marked at a point about 2 mi. down stream from Pit No. 3 powerhouse. At this point bed rock appears practically at the ground surface on the right bank of the river, but from this bank it drops below the stream reaching a depth of about 50 ft. at the left edge of the river channel. Beyond the left bank its depth increases. The design for the dam, therefore, calls for a composite structure, with a heavy overpour gravity section from the left edge of the channel to the right abutment and a lighter non-overpour structure at the left side. A heavy concrete division wall 30 ft. thick and 200 ft. in length resting on bed rock up and down stream along the left bank of the river will divide the two halves of the dam. Between this wall and the right abutment will be the overpour section of the dam, with heavy steel roller type gates surmounting its crest.

From the wall back for a distance of 200 ft. on the flatter, left hillside will be a non-overpour section of the dam, with heavy steel roller type gates surmounting its crest. From the wall back for a distance of 200 ft. on the flatter left hillside will be a non-overpour concrete barrier. The dam will rise 60 ft. above the surface of the stream and will have a total width of 430 ft., the overpour section being 150 ft. in width. There will be a large amount of difficult excavation for the foundation and about 50,000 cu. yd. of concrete will be required for the construction of this dam. The reservoir created by the raising of the waters will be of 2000 acre feet capacity and will serve as an after bay for Pit No. 3, as well as a forebay for Pit No. 4.

As at Pit No. 3, in order to enable the construction of the permanent dam foundation on dry bedrock there is in process of erection a temporary dam by which the river will be diverted into a timber flume which will carry the water past the permanent dam site to a point below where it will be returned to the stream. This temporary dam is of rock crib construction. The flume leading from this will be 11 ft. deep and 24 ft. wide, sufficient to carry a volume of 3500 second feet of water, more than the usual flow of the river between May 1 and December 1. The temporary dam is located 500 ft. upstream from the permanent damsite. The temporary diversion flume will be about 1600 ft. in length, its lower end being about 900 ft. below the toe of the permanent dam.

The entrance to the tunnel will be located 100 ft. upstream from the permanent dam. It will be 23,782 ft. in length, 19 ft. in diameter, of 3000 second feet capacity,

and can be driven from four headings. The intake at the head of the tunnel will be of the same general type as that of Pit No. 3.

At a point near the power-house end of the tunnel a short branch will connect with a concrete surge chamber cut into the side of the hill. The purpose of this, as at Pit No. 3, is to take up the surges in flow occasioned by fluctuations in the quantity of water being required by the power-house turbines. A spillway and waste pipe will carry waste water from the surge chamber to the tail-race.

From the lower portal of the tunnel three penstocks 129 in. in diameter will branch out through a manifold section. At the head of each pipe a butterfly valve will be inserted for the control of the flow. The penstocks will be about 1100 ft. in length, and will utilize a head of 377 ft. to deliver water to the power-house.

The equipment at Pit No. 4 power house will be of somewhat greater capacity than at Pit No. 3. It will consist of three 40,000-kv.a. generators. The transformer installation will consist of three banks of three 11,000-kv.a. transformers, with spares for emergencies.

Power to be generated at Pit No. 4 will be taken into the Pacific Gas & Electric Co.'s distributing system by means of 16 mi. of 220,000-v. double circuit transmission on steel towers, tying in to the main pit-Vaca lines at Round Mountain. Pit No. 4 and Pit No. 3 will be tied together by a single circuit tower at the same high voltage.

Construction camp capable of accommodating 200 men was built and equipped and transportation for machinery and supplies was provided by extending the Pit River railroad from Pit No. 3 power house, a distance of 2 mi. to the dam site, and 1½ mi. farther on to a flat on the river from which it is expected to obtain sand and rock for making concrete. The railroad passes the dam site at an elevation of 100 ft. above the river bed, this elevation affording the height and space required for the assembling of the concrete plant to be used in constructing the dam. After a while the railroad will be extended 6 mi. farther down stream to the power house, etc. An aerial cable way used originally on the Lake Spaulding development spans the river between towers high above the railroad. This cable way will provide transportation for men, material and equipment, back and forth, between the main railroad grade and the river bed.

Removing Alluvial Matter at Hydro Plants*

GRAVEL, SAND AND MUD, WHICH CAUSE EXCESSIVE WEAR IN WATER TURBINES, MAY BE AUTOMATICALLY AND CONTINUOUSLY REMOVED BY AN ELIMINATOR, TYPICAL INSTALLATIONS OF WHICH ARE DESCRIBED. BY HENRI DUFOUR

GRAVEL, SAND AND MUD are frequently a source of trouble in turbine installations which utilize the waters from mountain streams. In spite of care in the layout of intake works, a proportion of the solid matter

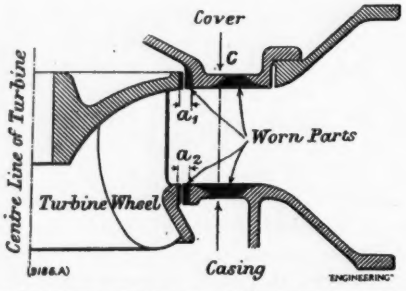


FIG. 1. EXCESSIVE WEAR AT POINTS SHOWN HAS NECESSITATED THREE TURBINES FOR ONE GENERATOR IN 24 YR.

penetrates into the supply canals, or head-race, and, depending on the rate of flow, either erodes the walls or settles in these channels and diminishes their effective cross-section. The inconveniences due to the interruptions of service and expense which may be involved in this way are well known, but in water turbine plants a further disability may arise from the wear which may take place in the pressure and discharge conduits; while what is perhaps the most serious of the disadvantages, which may follow from the use of water heavily charged with solid matter, lies in the wear which may take place in the hydraulic turbines themselves.

The quantity of solid matter which may be contained in hydro-electric water supplies varies.

In Francis type turbines, the alluvial matter wears and deforms the guide blades and the wheel. In Pelton turbines, the alluvial matter wears and deforms the end of the jet tube, the sharp edges of the buckets are worn away and the buckets themselves are deformed and sometimes even pierced.

Examples of water turbine wear due to the causes with which we are now concerned, occurred in two water power stations, each utilizing from 7000 to 10,500 cu. ft. of water a second under a head varying between 16 and 45 ft. At Station A, in 1919, the energy available for use, or sale, from this installation with the turbines in new condition, is of the order of 85,940,000 kw-hr. per year and, with the turbines in the state to which they had been reduced, some 64,950,000 kw-hr. There was thus a loss of possible output of some 20,990,000 kw-hr. per year. The whole of the turbines in this installation have had to be replaced. In the case of Station B, in twenty-four years of service, one generating unit has actually been fitted with three turbines, one after another. The parts at which most wear takes place in this case are indicated in Fig. 1.

An interesting case is the performances of a turbine at the Ackersand power station in Switzerland at the beginning and end of the summer of 1918—that is over the period during which the River Viege, which supplies the turbine, carries the maximum amount of alluvial matter. The turbine works under a head of 2240 ft. The machine is rated at 5000 hp. and during the period the output at a water consumption corresponding to half-load for the machine in new condition, fell off by 26.5 per cent, at three-quarter load by 18 per cent, at full load by 14.5 per cent, and at 10 per cent overload by 13 per cent.

Some further figures of interest which may be quoted have reference to the Klosterli power station in Switzerland, of which the maximum water supply is determined by the cross-section of a tunnel which feeds the head

*Abstract of an article published in Engineering, London.

race, and is limited to 105,000 cu. ft. per sec. The maximum fall is 697 ft., and the equipment consists of seven Girard turbines of 500 hp. and one Pelton wheel of 3500 hp.

The Klosterli station contains a wattmeter registering the total output, and the reading of this instrument over the period from June to October, 1917, is indicated by the broken line in Fig. 2. As will be seen from the broken line in the figure, an improvement was shown in October, following the successive replacement of the guide vanes of four of the 500-hp. turbines.

These are probably the first curves of this kind which have been published, and they may be summarized as follows: The total period of observation was 105 days; the total amount of solid matter carried by the water amounted to some 5220 to 5600 t. The output of the turbines, as compared with their output when new, fell by 10.4 per cent. As will be seen from Fig. 2, the main part of the alluvial matter appeared in two flushes, or waves, which in themselves were responsible for 95 per cent of the fall in output.

By September, 1918, the output had fallen by as much as 17.9 per cent. Replacement of all wheels brought the output in the winter of 1918-1919 to 99 per cent of that given by new machines, showing that the loss occasioned during 1917 and 1918 had been due to turbine wear. The hatched area at the top of the diagram shows the loss of energy during the months June to October, 1918.

The first step to be taken in dealing with turbines using the water from mountain streams is to arrange for frequent measurement of output and efficiency of the whole station if the machines cannot be dealt with independently. If all turbine stations collected the data necessary to construct a diagram of the type shown in Fig. 2, such a graph, with a knowledge of the hourly load and the price at which energy is sold, would permit an exact calculation of the loss which is being suffered.

At the Florida-Alta power station in Chile belonging to the Chilean Electric Tramways and Light Co., Ltd., of London and Santiago du Chile, large automatic eliminators, constructed according to the author's designs in 1912 and 1914, have rendered excellent service. The design has now been simplified and perfected, and no good purpose would be served by describing these early examples in detail.

The first modern installation with which it is proposed to deal is that at the Zermatt power station of the Gornergrat Electric Railway. This station, which has a capacity of 1000 hp., utilizes the water of the Torrent de Findelen. From the first, alluvial matter in the water proved troublesome, and two decantation basins one above the other were constructed in the rock in the narrow gorge down which the stream passes. It was found that these basins had to be cleared out as frequently as two or three times a day, resulting on each occasion in an interruption in the operation of the station and consequently of the train service. Serious machine wear resulted so that turbine guide vanes had to be replaced every year.

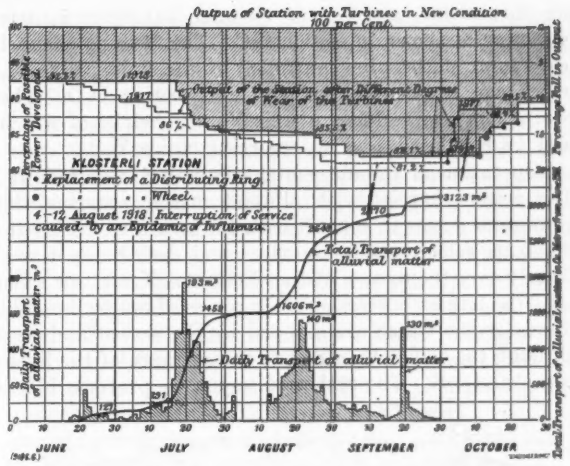


FIG. 2. CHART SHOWING AMOUNT OF ALLUVIAL MATTER PASSING THROUGH KLOSTERLI STATION AND LOSS IN ENERGY OF TURBINES CAUSED BY WEAR

In view of the conditions of the site making decanting basins side by side impossible, the installation was constructed out of one of the existing settling basins without increasing either its length or capacity. Its arrangement is shown in Fig. 3. The eliminator consists of a single decanting channel K fitted with two sets of screens and G_1 and G_2, which serve to quiet the entering water. Behind these a screen of finer mesh G_3 is situated. Along the center line of the basin floor a narrow passage E forming a sink has been cut. This communicates through a series of openings U_1, U_2 .. U_n with the flushing channel S situated below it and really form-

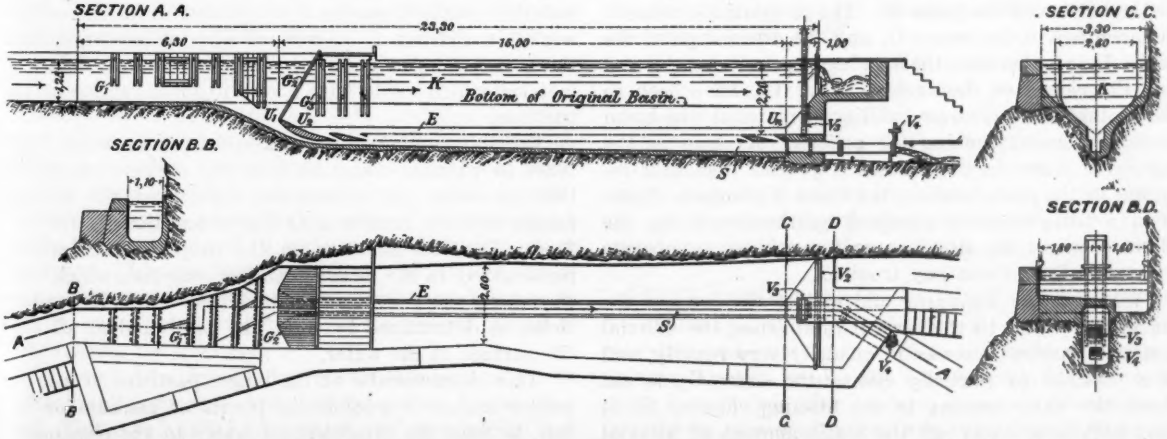


FIG. 3. AUTOMATIC ELIMINATOR AS INSTALLED AT ZERMATT PLANT OF GORNERGRAT ELECTRIC RAILWAY

ing part of the same central channel, but being a little narrower, as shown in section C-C. The flushing channel leads to an outlet pipe controlled by the sluice valve V_4, which can be seen in the plan and section D-D. The equipment also includes a weir V_2, the height of which may be regulated, and an emptying sluice V_3.

Operation of the automatic eliminator is as follows: The water charged with alluvial matter entering the eliminator comes in contact with the screen G_1. This reduces its velocity to some extent and distributes it uniformly over the section of the eliminator K. At the same time the largest pebbles or other pieces of matter brought down by the water are stopped by the screen and pass through the orifice U_1 direct to the entrance of the flushing channel S. The action of screen G_1 prevents block-

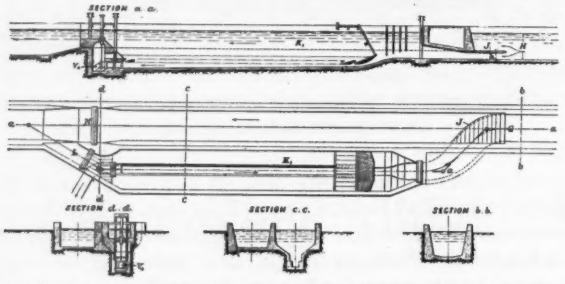


FIG. 4. LARGE AMOUNTS OF WATER CAN BE HANDLED BY A COMPARATIVELY SMALL ELIMINATOR, DESIGNED TO REMOVE MATTER FROM LOWER STRAIN ONLY

ing below the finer screen G_2, the duty of which is to trap such of the larger material as passes screen G_1, and especially large floating bodies. The screens G_2 and G_3 complete the stilling of the water, which after passing G_3 flows gently down the basin, allowing the solid matter it carries to sink on to the inclined planes which form the bottom of the sink. Since the sluice valve V_4 is open and the flushing channel communicates with the basin K through the orifices U_1, U_2, and soon a certain quantity of water, depending on the height of the water in the basin, passes out through the channel S. The rate of flow is sufficiently high to carry off all the deposited matter through the sluice V_4, whence it passes again into the torrent.

To fulfill their object, the sink E and the flushing channel S should evacuate automatically and continuously all gravel, sand and mud which are precipitated on the bottom of the basin K. The proportions between the openings in the screen G_1 and the dimensions of the orifice U_1, and between the openings in the screen G_2 and the dimensions of the orifices U_2 .. U_n, have been so chosen that there is no probability of material which can pass the screens choking the orifices. As long as the supply of water in the torrent is greater than that required by the power station, the sluice V_4 is open. Apart from a little cleaning required by the screen G_2, the plant requires no attention and continues to operate automatically without any trouble.

When at the beginning and end of the summer the amount of water in the torrent diminishes, the alluvial matter it carries decreases in quantity very rapidly, and it is possible, by partially closing the sluice V_4, to cut down the water passing to the flushing channel till it just suffices to carry off the small amount of alluvial matter that is deposited, while, if the very small quantity of water coming down the stream demands it, the sluice V_4 may be closed entirely. This provides for periodic automatic separation without any necessity for emptying the supply channel or deranging the service in any way. This possibility is an important advantage of the system.

The Gornergrat eliminator was put into service in June, 1921, and immediately had to deal with rapid variations in the amount of water in the torrent and great quantities of alluvial matter. The eliminator was in service during the summers of the years 1922 to 1924, both day and night without interruption, and without any attention other than the regulation of the sluice valve V_4 during periods of low water. Contrary to what had been the conditions before, the power station service has not been interrupted in any way during the whole season from June to September when the railway is open. The operation of the turbines has been considerably improved and the wear has become extremely small.

The automatic eliminator built by the Lima Light,

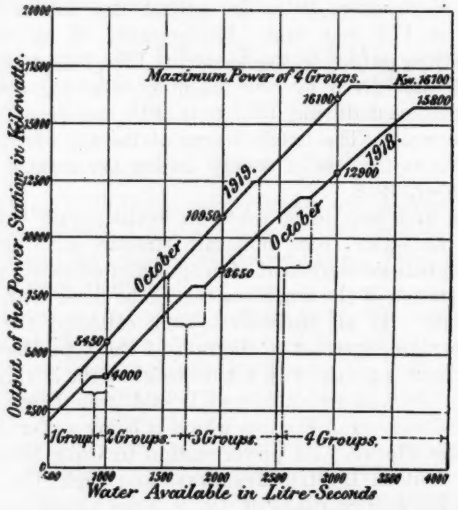


FIG. 5. OUTPUT CURVES OF ACKERSAND STATION, AFTER INSTALLATION OF AUTOMATIC ELIMINATOR

Power & Tramways Co., at its Yanacoto power station in Peru, furnishes another example. This station has an output of 15,000 hp. The Rio Remac, from which the water is obtained, carries much clinker from the copper works, in addition to its natural alluvial matter, so that the automatic eliminator in this case removes a class of material which would have a very injurious action on the turbines.

Precipitation of grains of alluvial matter which takes place in running water leads to the obvious conclusion that in rivers and canals the density of the alluvial matter is much greater near the bottom than at the surface. The concentration in the deeper strata applies particularly to the larger grains of material, which have the most serious effect on the turbines. These larger particles, as determined by tests, are not found at all near the surface of the water.

This characteristic of the larger particles of alluvial matter makes it possible, in plants of medium or low fall, to limit the treatment of water to the elimination of grains above a certain size and to employ an arrange-

ment of automatic eliminator which, while it prevents the formation of deposits, makes it possible to treat very large quantities of water in an installation of relatively small size. A plant of this kind, designed for Japan, is illustrated in Fig. 4. A shelf J situated some height above the bottom of the canal, as shown, separates the water flowing near the bottom of the channel from that above it, and turns the lower water into the automatic eliminator. This lower water which is only a fraction of the total, rejoins the main stream leading to the power house by the passage L, while the alluvial matter it carries passes to the river.

The efficiency of separation of automatic eliminators varies generally between the removal of all material greater than 0.008 in. in diameter and the removal of all material greater than 0.02 in. in diameter, but these figures may be passed in either direction if necessary. It will, of course, be understood that the eliminator will be larger as the dimensions of the grains to be separated are smaller. Any degree of separation may be guaranteed and obtained.

It may be suggested that, even if the automatic eliminators accomplish all that is claimed, they have the disadvantage of diverting a certain percentage of the water available, for flushing purposes. Experience has shown, however, that in practice this is no disability, since, at the time when large quantities of alluvial matter are brought down, the supply of water is always much greater than is needed for operation.

Before concluding, it will be well to refer to some actual results obtained in practice with automatic eliminators. Precise results are, in general, difficult to obtain, since their estimation requires considerable work, the taking of many observations, and the collection of statistics regarding a number of different factors.

In spite of these difficulties, the results obtained with some automatic eliminators can be quoted. The Ackersand power station originally possessed an old separator, which was flushed periodically, but which at certain times allowed water to pass to the turbines containing sand and pieces of gravel up to 0.47 in. in diameter. The wear on the machinery was such that it was necessary to replace three nozzles and a turbine wheel every year. The automatic eliminator, which was put into service in 1919, limited the size of the grains entering the machines to a diameter of 0.016 in. in diameter, and prolonged the life of the parts which were previously eroded in the proportion of about 1 to 3. Figure 5 shows the efficiency of the station in 1918 and 1919.

In view of the diverse conditions under which hydroelectric installations work, those most fortunately situated utilizing water which is always clear even under high-head conditions, the serious wear and the means of remedying it that have been dealt with in this article must not be too broadly generalized. Nevertheless, it can be said that whenever the water utilized carries solid matter which causes wear, there is loss from irregular operation, fall in output, and attendant expense for repairs. For all installations in which the economic utilization of the water available and the maximum output possible is aimed at, the data here put forward call for serious attention and consideration.

Proper Filters Aid Ice Plant Operation

FORMATION OF MUD-DECK, USE OF COAGULANT AND PROPER FILTRATION RATE DISCUSSED BY N. A. P. R. E. BY CHARLES H. HERTER

AT A RECENT meeting of New York Chapter No. 2 N. A. P. R. E., M. P. Robinson of the International Filter Co. presented an interesting lecture on "Treatment of Water in Ice Plants." The speaker said that uniformly perfect ice was everywhere in demand and that more ice plants ought to strive to improve the quality of their product. In some existing plants, limitations of space prevent the installation of amply large settling tanks and filters but, to meet the demand for better quality, new plants ought to be designed to accommodate the necessary equipment. Proper treatment of water sometimes eliminates pumping of cores from ice cakes.

FILTERING OF WATER

Filtration of city water has been practiced for many years. It originated in Europe, where the water was allowed to percolate slowly through sand filter beds measured in acres. Today we accomplish the same or better clarification by the use of higher rates of filtration which enable the same amount of water to be filtered in much less space. This was made possible by the introduction of a coagulant, which puts the water in better condition to be filtered, and by the development of the present system of back-washing the filter bed.

The sand filter depends for its efficiency upon a growth of mat-like substance on and near the surface of the filter sand. This mat is called "Schmutzdecke" (mud-deck) and seals the voids between the sand grains against the passage of suspended matter. The mud-deck in the slow sand filter plants was allowed to form naturally and this took considerable time. Since there was no other method of removing the dirt filtered from the water, it was allowed to accumulate as long as the pressure loss permitted and was then scraped off the bed. But now, by the use of alum, which is a weak acid, forming aluminum hydroxide with the alkalinity of the water, an efficient mud-deck is built up within a few minutes, and the accumulated dirt is readily disposed of by present-day methods of reversing the flow of water upward through the filter bed and discharging it to the sewer.

Settling the water after the coagulant is applied and before filtering gives the coagulant a good opportunity to form and permits the settling out of much of the dirt, thereby saving wash water. If the alkalinity of the natural water is not sufficient to react properly with the alum, artificial alkalinity can be established, and in the case of the smaller filters this is most conveniently done by the use of lump sodium carbonate or sal soda.

PROPER WASHING AND USE OF COAGULANT ESSENTIAL

Assuming a well-designed filter, the proper use of the coagulant and careful attention to the washing process is essential for good results, and it is desirable to filter to the sewer a short time after washing to permit the mud-deck to build up somewhat before using the filtered water. If it is possible to precede the actual filtration by settling,

even better results can be expected. It should also be remembered that the amount and condition of turbidity in water supplies varies from time to time, and the amount of coagulant should be varied accordingly to obtain uniformly good results. The amount of alum required may vary from one to six grains per gallon of water filtered.

The rates of filtration most commonly used now, stated in gallons per minute per square foot of filter bed surface are: 1 to 2 for bacterial removal for drinking purposes, 3 for industrial uses and 4 in unusual cases where the character and use of the water permits.

Where the water is discolored by vegetation, a common condition in our Eastern States, filtration alone is not sufficient, but special arrangements must be provided for absorbing the color and filtering out the absorbing medium.

A good filter bed is composed of hard silica sand and gravel. The gravel supports the sand so that it can not pass out of the filter, and also assists in the distribution of the wash water beneath the sand during the washing process. The natural round sand grains are to be preferred to the sharp manufactured quartz. The sand is carefully graded as to uniformity and size. Samples of good quality filter sand 1/32 in. and 1/16 in. were exhibited, and it was observed that the grains were practically round and almost uniform in size. A typical filter bed is composed of 24 in. of sand supported by three or four 4-in. layers of gravel, the gravel grading in size from ¼ in. to 2 in. at the bottom of the filter.

Water softening by the zeolite process was briefly described. Zeolite (Na Z) is a sodium compound which exchanges its sodium for the hardness in the water. A sample of synthetic zeolite was exhibited. It resembles coarse (⅛-in.) white granulated sugar, and is harder than glass. Occasionally it is used for treating raw water ice, but its chief application is in the softening of water for boilers, laundries and textile processes.

Discussion of Paper

Discussion of Mr. Robinson's paper brought out the following facts: Paper disk filters, while effective, are acceptable only for small quantities of water per hour. The rates of flow given above are not to be exceeded. No special advantage is found in the use of marble chips. Where the water is to be deodorized, bone charcoal is effective but difficult to keep in good condition.

Channeling occurs in pressure filters because of attempts to force too much water through a filter, or because the filter bed is not properly washed, thereby causing the water to force its way through only a portion of the bed. The best way to operate a number of filter units is in parallel and not in series. With the same size and number of filters, a given amount of water can be filtered better if the filters are connected in parallel. What is gained in series filtration by the passage of the water through more than one filter bed is lost by reason of the higher rate at which the water must pass through each bed.

To the foregoing the writer wishes to add that an engineer may keep the mechanical equipment of his plant in perfect operating condition, but if he neglects the quality of his water, he cannot expect to produce perfect ice. There is probably not one plant in a hundred where the water always is so good as to require no attention or treatment whatever. Filter companies with ample experience hold out their helping hand.

Connecting Ammonia Gages

Proper Location of Gages Is Important for Satisfactory Compressor Operation. By J. F. Staley

IN OPERATING refrigerating machinery, one of the things most often overlooked is the proper connection of ammonia gages to the ammonia compressor. Great stress is laid, especially in examination, on the proper connection of steam gages to steam equipment and the reasons for such connections. But when talking about ammonia compressors this point is seldom mentioned.

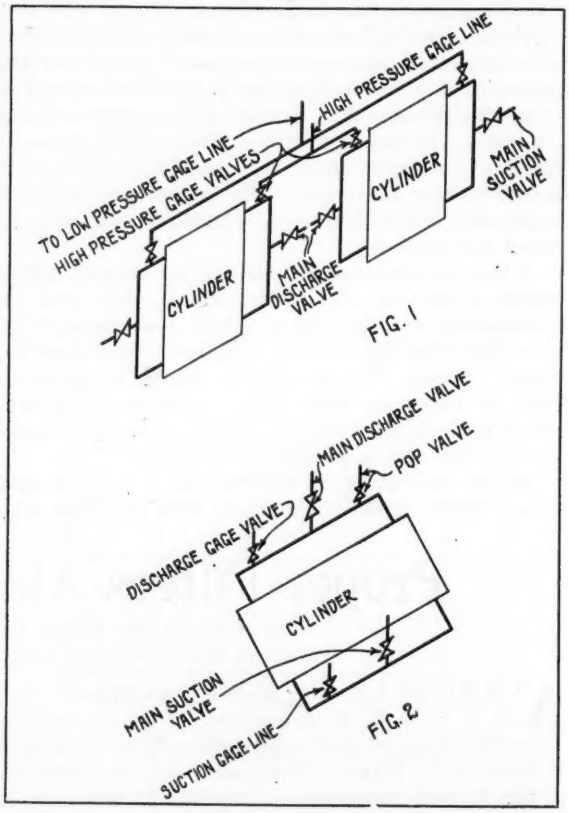


FIG. 1. GAGE LINES SHOULD BE CONNECTED THUS FOR A TWO-CYLINDER COMPRESSOR

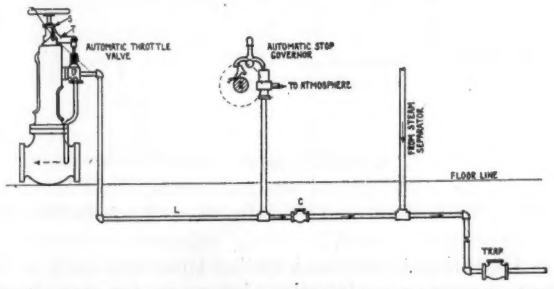
FIG. 2. THIS GAGE CONNECTION, FOR A SINGLE CYLINDER MACHINE, SHOULD GIVE PROPER INDICATIONS

For proper operation, the suction gage should be connected between the main suction valve on the main ammonia line and the compressor cylinder, so that in starting the compressor the suction pressure can be easily determined. In case any part of the system is pumped out through a separate pump-out-line, this gage will also show the pressure or vacuum on the pump-out line. This connection is shown in Figs. 1 and 2.

In a similar way, the discharge gage should be connected between the cylinder and the main discharge valve. In case someone forgot to open the discharge valve when starting the compressor, the gage would show excess pressure and the engineer would be informed at once that something was wrong and that the pop valve would soon operate. If there were no pop valve installed, there might be danger of a gasket blowing out or of some other part of the equipment being damaged. Of course, gages should be located so that the man operating the compressor can face them and at the same time observe the action of the machine.

Intermittent Steam Trap Causes Power Interruption

OUR PLANT is equipped with a small turbo-generator unit which is running in parallel with central station power. As shown in the accompanying figure, an intermittent steam trap was installed to keep the steam loop *L* between the automatic throttle valve and the automatic stop governor drained of all condensate. This trap also drains a separator in the turbine steam line, a check valve being placed between the drains to prevent the steam coming by way of the steam separator drain, from keeping pressure on the loop when the



INTERMITTENT ACTION OF THE STEAM TRAP TRIPPED THE THROTTLE AND STOPPED THE GENERATOR

automatic governor operates. The arrangement of the throttle, automatic governor and trap are shown in the diagram.

Action of the automatic stop governor and throttle is as follows: steam enters on top of the balanced piston in cylinder D and leakage which passes the piston equalizes the pressure on both sides and also keeps full pressure on the loop *L*. This piston is operated by a differential pressure created in the cylinder by the action of the automatic stop governor. This releases the pressure in the loop and under the piston to the atmosphere, causing the piston to drop. The lever *T* then trips the disc *S* and the throttle closes. The automatic stop governor acts only when the predetermined speed limit of the turbine is exceeded.

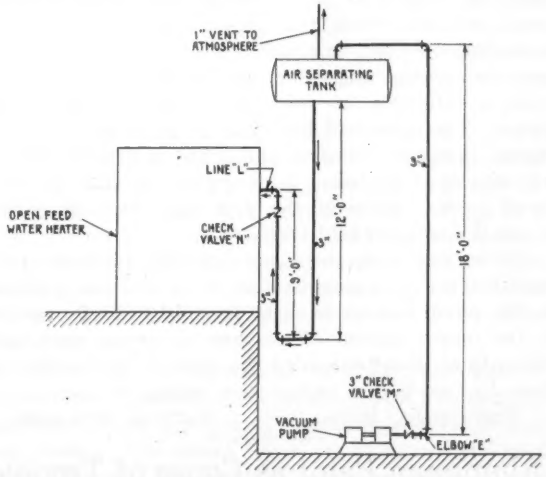
Because of the pressure being balanced on both sides of the check valve *C*, it remained closed until condensate having sufficient weight to open collected on the loop side. When the intermittent trap discharged, it caused a sudden rush of steam and condensate from the loop toward the trap. The resultant pressure drop in the loop caused the piston to become unbalanced and the throttle tripped, acting the same as if the automatic safety stop governor had operated. The turbo-generator dropping its load on the central-station-power transformers, overloaded them and the overload relay opened the switch, thus cutting the power off completely.

The cause of the trouble was not detected the first time, but when it occurred again an investigation disclosed the conditions as outlined. The trouble was remedied by installing a continuous flow trap on an individual drain from the steam loop to the turbine automatic safety stop governor.

Collingswood, N. J. G. EMERSON TAYLOR.

Pump Troubles Caused by Sacks in Line

IN THE accompanying figure is shown a vacuum pump which handles the returns from 15,000 sq. ft. of radiation and the way the discharge line was installed



THIS SHOWS THE PIPING ARRANGEMENT FOR THE VACUUM SYSTEM ON AN OPEN FEED WATER HEATER

to deliver the condensate to the open feed water heater under 5 lb. back pressure. As shown, the returns are delivered to an air separating tank, from which they flow by gravity down through the loop and into the heater.

As installed by the piping contractors who stated that other similar installations were working satisfactorily, the air vent from the separating tank to the atmosphere was extended 4 ft. 8 in. above the tank and then horizontally through the wall to the atmosphere. No check was put in the water leg between tank and heater. When things were started up, the vent to the atmosphere discharged an almost continuous stream of water, while the hammering in the drop leg was quite annoying.

Why something did not break is beyond understanding. At the coming of the first cold weather, the 1-in. vent pipe froze up, so no more water went out on the roof, but all the air went down the drop leg and into

the heater. Soon serious trouble started. The 3-in. pipe entering the heater at L started pitting and had to be renewed twice in 4 mo. Besides this, after the vent pipe froze up, the vacuum pump almost pounded itself to pieces. It would race and pound, with the vacuum up and down until everybody was thoroughly disgusted with the equipment.

To make matters still worse, the valve stems in the vacuum pump would break and the springs go out the discharge. The 3-in. check valve in the discharge line, next to the pump at M hammered its seat and check out in three weeks.

After a fight with the operating crew, the construction gang quit the job and it seemed like a hopeless task to find the cause of all the trouble. Having on hand a 3-in. vertical check valve, I put that in at N. That stopped the water hammer in the drop leg. Then the 1-in. vent was carried up inside the building 25 ft. and back down to the sewer. Water still was carried through it and the separating tank would hammer.

About everything we could think of was tried without any lasting success. At last I saw an advertisement for a device called an air eliminator. This was installed and the hammering in the tank ceased but the valve stems still continued to break. Finally, I thought of installing a gage on the discharge line of the vacuum pump and discovered 20 to 29 lb. pressure. After disconnecting this line, at elbow E we found a large gunny sack, two cement sacks, the remains of an old shoe and quite a collection of valve stems, springs and valve plates. The sacks had been put in there when the discharge line was installed and quite a little ingenuity was displayed in doing it. Copper wire had been soldered to the inside of the pipe and the wire wound round the sacks to hold them.

After removing the souvenirs, the discharge pressure dropped to a maximum of 12 lb. and the governor on the pump was set to carry from 10 to 11 lb. vacuum in the return mains. Since then the pump runs satisfactorily at about one-third the speed it ran before and there has not been a broken stem, spring or valve.

Minneapolis, Minn. FRED S. RUTLEDGE.

Aluminum Paint as Cause of Trouble

RECENTLY a customer returned to the manufacturer some samples of oil taken from a transformer which had failed. The oil had been found dirty, and seemed to carry a large amount of black sediment for which the customer could not account.

Analysis of the oil showed small quantities of aluminum, for which the laboratory could give no explanation. The findings were reported to the customer, with a request for a possible explanation of the aluminum.

The matter was cleared up in a letter which read:

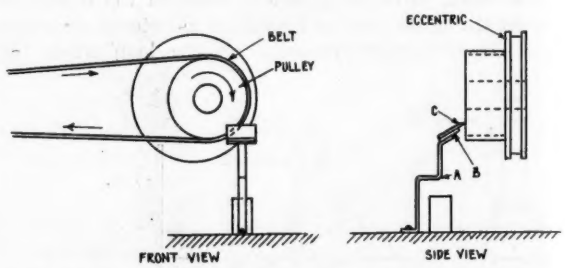
'The surprising results which you found, showing aluminum in the oil, undoubtedly is due to our using aluminum paint on the transformer tanks in the building. This was applied with a paint spray which no doubt saturated the atmosphere in the building with aluminum which was taken into the transformers through the breathers.

"This analysis therefore has given us a valuable suggestion, and in the future we will see to it that the breathers are closed when aluminum paint, or any paint with a spray, is used." MANUFACTURER.

Simple Device Keeps Oil Off Governor Belt

IN MANY steam plants it is a common sight to see a governor belt literally soaked with oil. Needless to say, this is a dangerous condition for many engine wrecks have been traced to oily governor belts. A slipping governor belt is really more dangerous than one that will come off entirely.

I once had a belt that continually gathered oil which I not only had to wipe off twice a day but could not locate the source of trouble. Finally I made the device shown in the accompanying figure. This not only removed the oil but even recovered about a pint a week. A sharp edged piece of leather, C, was riveted to a ⅛-in. strip of iron, B, about 10 in. long and bolted to the floor. As the governor pulley revolved it removed the oil which ran down to A and dropped off. The set screws in the governor pulley opened a space between the pulley hole and the shaft and the oil from the eccentric ran through and down the side of pulley onto the governor belt.



THIS SIMPLE DEVICE KEEPS OIL OFF THE GOVERNOR BELT

Until this device was installed I had to supply a new belt every year, as did others before me for many years. Since then the same belt has been giving satisfactory service for several years.

Malden, Mass. SAM BOW.

Feed Water Heaters Economical in Any Plant

POWER PLANTS having one boiler only are still in existence. Often it is at such plants that boiler accidents occur, because it may mean financial loss to shut down the plant at regular intervals for proper boiler cleaning. The owner of such a plant told me his engineer had informed him the installation of a feed water heater would be a needless expense as they were using an injector which heated the water entering the boiler. Of course, I told him the engineer was mistaken, that it was quite possible for a feed water heater to be as profitable an investment in a small power plant as it would be in a larger one and that economy in the small plant was quite as important as in the large one.

I explained to him that because he had only one boiler, the heater was practically a necessity for the reason that a feed water heater and purifier combined greatly assisted in preventing the accumulation of scale and oil inside the boiler. This would mean greater safety, reduced labor and a saving in fuel. I advised him to install a steam operated pump for the feed water, using the exhaust in the heater or elsewhere, as he had several steam heated ovens in use.

He could readily understand the advantages of such a heater when shown that there would not be as great a danger in operating the boiler over a considerable period continuously with a heater and purifier in use as there would be without one. He said, "I guess a heater will cost a lot less than another boiler and as you describe things, it means one or the other, so the logical thing to do is to install the heater and as I have none too much cash on hand I will do so."

This owner saw clearly the difference between forcing raw water into the boiler with an injector and high temperature water taken from the heater by a pump. There was no difficulty in making him understand that a heater and pump would soon pay for their cost by reducing fuel and labor costs and permitting better service. All this owner needed was to have the matter clearly explained to make him actually eager to purchase the heater and pump. He had little or no practical engineering knowledge in power plant matters, but was willing to spend money if he could be assured of appreciable savings by so doing.

In many small plants, engineers make a mistake by failing to impress their employers with the necessity for desirable equipment, even if it means that the engineer will be expected to help with the work of installation. In plants having one boiler only the engineer often is the only one in the building that has any practical knowledge of steam engineering and he is negligent of duty if he fails to use his knowledge for the benefit of his employer.

Engineers in large power plants or those who read only the descriptions of these plants often get the impression that the small plant is non-existent, or at least is not worth worrying about. There are thousands of these small plants scattered over the country and the amount of money invested is quite appreciable. Engineers in the power plant field, no matter what their status, should give some thought to the problems of the small plant.

Toronto, Canada. JAMES E. NOBLE.

Can an "Arch" Be Flat?

WHAT does a real "arch" look like? The dictionary says an arch is "a concave construction of stones or other materials over an open space." Arches have been built for thousands of years.

Genuine arches were once built in boiler furnaces. Today, however, the word "arch" is rapidly becoming a misnomer. Look into a modern furnace and almost invariably the roof over the grate will be found to be perfectly flat—not "arched" at all. Yet, because of its arched ancestry, the name "arch" will probably be used for some time. I think the word "roof" should be used. Call it a "flat furnace roof" or an "arched furnace roof" as the case may be.

Actual arches preceded boilers by many centuries but combustion arches were scarcely used until the advent of the Stirling boiler. Shortly after, came the natural draft chain grate stoker and with that stoker came more combustion arches. Since then and until recent years there has been but little improvement in the design and construction of combustion arches. In fact, many arches nearly 30 yr. old in design are still in use.

Originally the Stirling boiler arch consisted of two real old-style arches, namely, (1) the ignition arch and (2) the baffle arch, which was placed above and in front of the ignition arch. The function of the ignition arch was to give more rapid and better ignition to the fuel by producing an intense heat reflection. The function of the secondary or baffle arch was to deflect the gases of combustion into the first bank of tubes and compel an earlier absorption of the heat, giving the gases a longer travel through the tubes with resulting higher heat transmission efficiency. This arch therefore performed no function in the combustion of the fuel. In designs calling for step-up arches the construction of furnaces was still further complicated.

Until 1901 the genuine old-fashioned concave arch was the only type used. Then the first "flat arch" was patented and placed on the market and since that time other "flat arches" have been patented and placed on the market. The "flat arch" soon demonstrated its superiority over the old-fashioned type.

As is usually the case the earlier designs were largely arbitrary and such factors as kind of fuel, size of equipment, boiler rating, etc., were not given much consideration both because of ignorance and lack of appreciation of their importance. Besides during this earlier period fuel was cheap and labor and material costs were low. There was little incentive for scientific improvement.

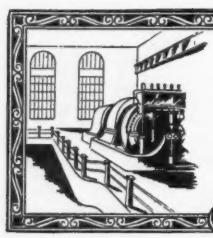
Fuel rapidly increased in price, however. Low grades of fuel gradually came into use with the general adoption of the chain grate stoker and with them the problem of initial and sustained ignition became of increasing importance.

Years of usage proved that old-fashioned arches had their limitations and objections. The limitations were largely constructional but from a combustion standpoint it was generally agreed that a concave top surface is not ideal for an even fuel bed. In addition, old-fashioned arches always involve the separate arch support of curtain walling and in many cases the necessity of secondary arches. These conditions seriously increased the difficulties of air sealing.

The recent development of the "flat arch" has to a large extent remedied these faults. From a construction standpoint there is practically no limit today as to length and width. The entire "arch" is at a uniform height above the fuel. The lower, or reflecting surface is a true plane, which is the ideal condition.

Experience has demonstrated that an arch of some kind is necessary for the proper ignition and sustained combustion of fuel. While this is the primary function of arches other important conditions relating to furnace efficiency and capacity also enter into furnace design. One condition that is rapidly coming into prominence is the smoke problem. It is now well known that correct combustion eliminates smoke. Largely because of non-recognition of these relations and lack of early knowledge of the science of combustion, development has necessarily been slow. The proper design, construction, and location of furnace arches so that they will perform their intended function is as much a scientific problem as is the designing of a boiler or stoker.

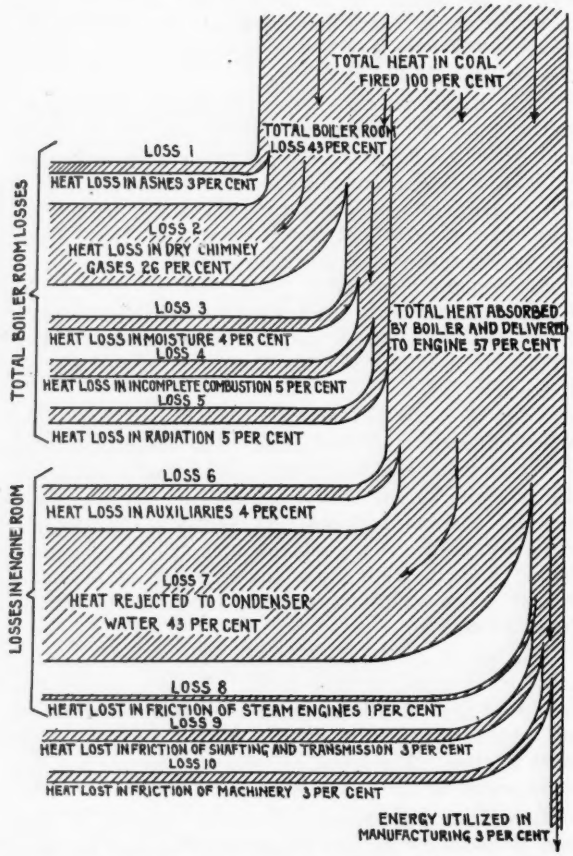
Many engineers even at the present time are prone to accept the fantastic and gamble with untried principles. Whereas the changing of the simplest detail may be helpful in some instances it surely will not cure all ills. After all is said the best guides are—facts based upon trials and experiments. W. F. SHAPHORST.



QUESTIONS AND ANSWERS

Small Per Cent of Coal Energy Utilized

In the average manufacturing plant using steam engines connected by belts to line shafting, what are the various items of energy distribution and losses, from the point of coal firing, to the application of power to the manufactured article? H. R. T.


TOTAL HEAT IN COAL FIRED 100 PER CENT
TOTAL BOILER ROOM LOSS 43 PER CENT
LOSS 1
HEAT LOSS IN ASHES 3 PER CENT
LOSS 2
HEAT LOSS IN DRY CHIMNEY GASES 26 PER CENT
LOSS 3
HEAT LOSS IN MOISTURE 4 PER CENT
LOSS 4
HEAT LOSS IN INCOMPLETE COMBUSTION 5 PER CENT
LOSS 5
HEAT LOSS IN RADIATION 5 PER CENT
TOTAL BOILER ROOM LOSSES
TOTAL HEAT ABSORBED BY BOILER AND DELIVERED TO ENGINE 57 PER CENT
LOSS 6
HEAT LOSS IN AUXILIARIES 4 PER CENT
LOSS 7
HEAT REJECTED TO CONDENSER WATER 43 PER CENT
LOSSES IN ENGINE ROOM
LOSS 8
HEAT LOST IN FRICTION OF STEAM ENGINES 1 PER CENT
LOSS 9
HEAT LOST IN FRICTION OF SHAFTING AND TRANSMISSION 3 PER CENT
LOSS 10
HEAT LOST IN FRICTION OF MACHINERY 3 PER CENT
ENERGY UTILIZED IN MANUFACTURING 3 PER CENT

STARTING WITH 100 PER CENT HEAT ENERGY IN THE COAL, THE AVERAGE INDUSTRIAL PLANT LOSES OVER 90 PER CENT OF THIS ENERGY BEFORE USEFUL WORK IS DONE

A. This question may be answered briefly by referring to the accompanying diagram, which shows that with 100 per cent heat energy in the coal as fired, there are 10 items of loss before power is delivered to the article to be manufactured.

This represents an average plant using steam engines equipped with condensers but even here there is 43 per cent of the original heat energy lost to the cooling water. The next largest item of loss is the heat carried away by the dry chimney gas, the average being 26 per cent. Eventually there is only 3 per cent left to do useful work.

This heat balance diagram was taken from data obtained by the Bureau of Mines a few years ago.

Comments on Corliss Engine Diagrams

In commenting on the indicator diagram on p. 339, March 1 issue, the writer would suggest hanging the length of the connecting rods between the wristplate at the exhaust valve, thus causing the latter to open earlier and close later. This will lessen compression and give more power. If these changes were made, the engine could be given a longer cutoff.

One might look for a defect in the dash-pot as causing this engine to hold over. It is assumed that this engine is of the automatic cutoff type.

Diagram No. 2 shows admission being a little late.

Tomahawk, Wis. O. H. Heil.

Lower CO_2 With Oil Than Coal

Why do most of the CO_2 recorders or indicators have a scale for per cent CO_2 graduated from 0 to 21, when in actual practice the amount of CO_2 scarcely ever goes above 16 per cent? What is the maximum amount of CO_2 that can be obtained with any fuel and is there a formula for figuring this? Why is the maximum higher with coal than with oil firing? C. B. D.

A. Since the amount of oxygen in the air by volume is 20.9 per cent, if a fuel composed entirely of carbon were burned completely, with no excess air, the amount of CO_2 formed would be 20.9 per cent. For this reason the scale is graduated from 0 to 21, although there is no need of doing this, since it will be pointed out that this amount of CO_2 never is obtained in actual practice.

When there is sufficient air for complete combustion, carbon unites with oxygen according to the following equation:

$$2C + 2O_2 = 2CO_2.$$

This shows that for each volume of oxygen there is one volume of CO_2 formed.

In actual practice there is no fuel composed entirely of carbon, but all commercial fuels contain hydrogen in varying amounts. When such fuels are burned, only the product of the combustion of carbon remains as a gas to be determined volumetrically in an Orsat or CO_2 recorder. When hydrogen is burned it unites with oxygen to form water vapor which condenses and is not measured in the gas analysis.

In solid or liquid fuels the combustible constituents are carbon, hydrogen and sulphur. Sulphur burns to SO_2 and since this gas is absorbed by the same reagents as CO_2 it could be reported as CO_2. This might lead to a serious error in combustion calculations if it were not for the fact that the amount of sulphur in most fuels is comparatively small and also that 1 lb. of sulphur requires only 1 lb. oxygen for complete combustion, whereas 1 lb. of hydrogen requires 8 lb. of oxygen and 1 lb. of carbon requires 2.67 lb. oxygen.

It may be seen, therefore, that even where the amount of sulphur is considered high, as with mid-western coals,

the amount of SO_2 formed is quite small. In addition, this gas has an affinity for water which will cause it to be absorbed by the water in the gas collecting or analyzing apparatus. Sulphur, therefore, may be considered negligible.

Let us assume that a sample of dry Illinois coal contains 65 per cent carbon and 3.15 per cent available hydrogen. Complete combustion of 1 lb. of this coal will be represented by the following equations:

Carbon ..... $0.65 \times 2.67 = 1.74$ lb.
Available hydrogen ..... $0.0315 \times 8.0 = 0.25$ lb.

Total weight, oxygen ..... 1.99 lb.

Of the 1.99 lb. oxygen used, only 1.74 lb. reappears in the form of CO_2 in the gas analysis. This is equivalent to $\frac{1.74}{1.99}$, or 87.5 per cent. This means that only this fraction of the 20.9 per cent oxygen in the air appears in the furnace gas in the form of CO_2, together with the 79.1 per cent nitrogen always present in air.

Accordingly, in terms of air originally supplied for combustion, there is left in the gas sample only 20.9×0.875 or 18.3 per cent of the original oxygen, in the form of CO_2, plus the 79.1 per cent nitrogen, making a total of 97.4 per cent. Since analysis is made on the basis of this mixture a 100 per cent sample would contain $\frac{18.3}{97.4} \times 100$, or 18.8 per cent CO_2, which is the maximum possible when burning fuel of the foregoing analysis.

Calculation of the maximum theoretical CO_2 with complete combustion may be greatly simplified by using the following formula, which was developed by combining the foregoing steps in calculation:

$$M = \frac{20.9}{1 + \frac{2.37\,H_a}{C}} \qquad (1)$$

where M = maximum theoretical per cent CO_2; H_a = available hydrogen, dry basis; C = per cent ultimate carbon, dry basis. Available hydrogen = hydrogen $- \frac{\text{oxygen}}{8}$.

In developing this formula it is first written:

$$M = \frac{20.9}{1 + \left(\frac{8H_a}{2.67C}\right) \times (1.00 - 0.209)} \qquad (2)$$

Here the term $\frac{8H_a}{2.67C}$ is a way of expressing the fact that for every pound of oxygen burning to CO_2 there is a certain fractional part of a pound of oxygen which burns to water and consequently does not appear in the analysis. This term may be simplified to $\frac{3H_a}{C}$ and then, multiplying by $(1.00 - 0.209)$ or 0.791 we get $\frac{2.37H_a}{C}$.

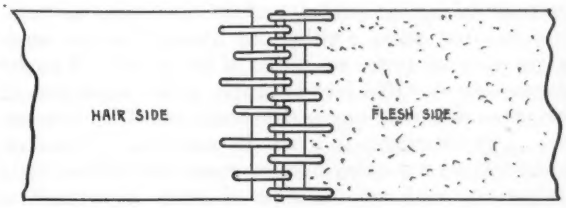
Since the amount of nitrogen in the air is definitely fixed, being always 79.1 per cent, and is found by subtracting 20.9 per cent from 100, equation (2) is put on the basis of a 100 per cent sample by introducing this figure of 0.791.

From the foregoing calculations it easily may be seen that the higher the available hydrogen content of a fuel, the less will be the maximum amount of CO_2 possible. For this reason it always is lower with oil than with coal firing.

Proper Method of Applying a Quarter Turn Belt

PLEASE tell how you put a quarter-turn belt on the pulleys so that there will be equal tension on both edges of the belt and the belt will not be stretched or strained entirely on one edge. J. T. T.

A. This can be done by giving one end of the belt one turn through 180 deg. before splicing as indicated in the accompanying sketch. In this sketch I have indicated the flesh side of the belt by means of dots and the hair side I have left plain. Thus, after being joined together you will have both the flesh and hair sides on the outside as well as on the inside.



THIS IS THE PROPER METHOD OF LACING A QUARTER-TURN BELT

The action of a belt spliced in this way is to turn itself over every revolution of the belt so that the maximum tension is first on one edge during one revolution and on the other edge during the other revolution. Usually it works out quite satisfactorily.

Of course if the belt is a double belt there is no flesh side, but one should have no difficulty in giving one end of the belt one turn as instructed above.

Newark, N. J. W. F. SCHAPHORST.

Wetting Coal Is Advisable

IS IT advisable to wet soft coal before hand-firing? N. C.

A. Wetting soft coal, if properly done, is a commendable practice and should be observed by all firemen. There is danger, however, in promiscuous wetting, since if too much moisture is applied it will result in an actual loss rather than in a saving. Different coals require the addition of different amounts of moisture for efficient combustion. This additional moisture should be added uniformly and should not be enough to make the coal have the actual appearance of being wet or cause it to cake.

FRENCH & HUBBARD, Boston, engineers, are preparing plans for a $1,000,000 power house for the Cambridge Electric Light Co., Cambridge, Mass. Contracts are expected to be let so work may start about May 1.

EDITORIAL COMMENT

What Instruments Are Absolutely Essential

In every power plant are hundreds of places where the B.t.u.'s can escape and to find these places and stop the leaks is the work of the operator. Many of these losses may be discovered by the exercise of his senses but the operator cannot determine the extent of the losses in this way, nor can he detect, without the aid of the proper instruments, many of the most serious losses.

When requesting the owner of a plant to purchase instruments for the guidance of the operators, the engineer is often asked whether the instruments are absolutely essential to the operation of the plant. If power plants were operated just to supply power regardless of cost, then many of our instruments would be unnecessary. The engineer is given to understand, however, that he must not only produce power but deliver it in competition with other sources of power at a profit to the owner.

How can this be done when, without a CO_2 meter, he cannot determine within 10 per cent the efficiency of combustion; when, without a flue gas thermometer, an unusual amount of scale may accumulate in his boiler undetected; when, without flow meters, he has no guide as to the proper distribution of load among boilers; when, without a power factor meter, his electrical losses may place an unnecessary overload on the plant.

Those instruments are absolutely essential which, first, insure safe operation of the plant, second, enable the keeping of cost records and, third, guide the operator in making savings sufficient to pay good dividends on the cost and maintenance of the instrument. Power plants should be equipped accordingly.

Complete Records Should Be Kept in the Hydro Plant

During the past few years, considerable attention has been paid to the keeping of records in the steam power plant. But as far as we have been able to determine, equal emphasis has not been laid on the keeping of adequate records in the hydro-electric plant. This point is forcibly brought out in an article in this issue by Henri Dufour describing eliminators for alluvial matter in water turbine supplies. This is a matter of vital interest to European plants using water from mountain streams and, M. Dufour brings out strongly the point that no hydro plant can tell definitely whether such equipment is needed or not unless complete and continuous records of station output and efficiency are kept, together with records of the alluvial matter carried by the water over the same period.

A diagram in the article shows how, at the Klosterli station, the output dropped almost 20 per cent below that of the machines when new, on account of wear, and in a period of 105 days the total solids carried by the water amounted to about 5000 t. It must not be assumed that conditions everywhere, even in mountain districts, are similar to this and that every plant must necessarily have an eliminator. M. Dufour is quite insistent on this point. But, until water conditions are determined as regards the alluvial matter, it is impossible to tell how much of the turbine wear must be credited to dirt or whether it is necessary to install eliminators. Careful tests have shown, for example, that, in certain cases, the bulk of the alluvial matter was carried in the lower strata of the stream. Consequently an eliminator could be designed to handle only these lower strata of water, thus making possible an eliminator of large capacity in a comparatively small space.

Whether such methods are necessary or desirable in American practice is, of course, open to question. Judging by the seeming scarcity of information on the subject, however, we feel that the subject has not been given all the attention it deserves. It is only one of the factors entering into the operation of a hydro-electric plant but the data presented by M. Dufour show the necessity for at least giving it consideration, by keeping adequate records of all the items involved.

Sound Fundamental Preparation Is Required for Engineering Training

Believing a man's earning capacity, a measure of his value to the organization, was determined largely by material desires, a midwestern industrial leader of the last decade started an unusual custom. From his organization a number of men were selected, each year, and shown the purchasing value of money at the company's expense. Good clothes, luxuries, trips to New York and Europe, the best accommodations and experienced advice were directed toward one objective, to awaken man's natural desire for ease and luxury, to add a material and tangible incentive to his desire for success.

Our educational system is yearly turning out thousands with an education, or semblance of an education, instead of money to fan the flame of ambition. The effects of the two are very much the same, they may be used for the general good of the profession, of humanity, of the individual, or as something to be hoarded as a miser hoards gold.

The men selected by this captain of industry were educated, experienced; capable men whose ambitions needed a jar to bring out their ultimate worth to the company; picked men with every chance of success. Our educational system, on the other hand, must take all comers and endeavor to turn out a creditable product. Many of those being educated have not the capacity to learn, others have not the initiative. Obviously, all men are not equal mentally. Psychology, although

helpful, does not permit accurate vocational forecast. The system is democratic, in that its standards are set by the average, and autocratic, in that its progress is limited by the intelligence or training of the minority.

A few would succeed regardless of their education. This is particularly true in many industrial pursuits which do not require technical training. Engineering, in all its branches, however, rests upon a foundation built up by hundreds of years of human progress. Education covering this entire period, crystallized by time into experience, tempered by natural ability and initiative will determine a man's worth to the profession.

For the engineering college, proper preparation is a prime requisite, if the college is to complete its obligations in a definite time and turn out the graduate, not only with ambition but with suitable means of gratifying that ambition.

With the proper fundamental and more, or less, uniform preparation, the entrants start on a common basis and progress is determined by the capacity of the average. Those who have not the intelligence or capacity to keep up with this group must, of necessity, be eliminated in order to prevent them from retarding the progress of others. Upon graduation, the young engineer may drift into any one of a dozen phases of his particular branch of engineering; his education must be general enough to permit intelligent progress in any one and, at the same time, fundamental enough to permit his continuation of specialized study in the particular field in which he finds himself.

Our entire educational system has been slowly changing. Although the preparatory schools are becoming of increased value to the community by meeting a popular demand and catering to the manual training of the majority who do not go to college, the education of the minority upon whom we depend for future scientific and industrial development must not be neglected.

Off Duty

This morning we started out rather ambitiously to write a ponderous dissertation on some abstruse scientific subject, just now we don't recall what it was all about—it might have had something to do with the effect of CH_3OH on the speed of Hibernian stoker equipment but it doesn't matter; we didn't finish it. The fact is, we were not in the mood. The warm spring sunshine and balmy air had cast its spell over us and each time we wrote the first paragraph we tore it up because the stuff we wrote sounded like poetry.

And perhaps it is just as well. Who cares about such high sounding jargon at a time when all of nature conspires to lure you away from your chosen occupation. Personally, as we have indicated, our inclinations this morning are toward the making of verses.

But the making of verses is not considered a reasonable occupation for the presumably dignified editor of an engineering journal, so rather than run the risk of being thought queer, we repress our versifying desires and do what we are supposed to do; that is, write this Off Duty article. As you will perceive, however, this repression has its inevitable Freudian consequences.

Now this business of writing Off Duty articles is not what it's cracked up to be. In the first place, when we are writing them we are not Off Duty since, if we were, we probably wouldn't be writing them. In the second place, we cannot always say what we'd like to say, for technical journals, as you must know, have policies and rules and these policies and rules must not be violated. So we desist from voicing our revolutionary impulses (we all have them) and write nice little articles which we trust, with the grace of the gods, will keep us out of deep water.

Like most mortals, we shrink from drawing the scorn of people just as foolish as ourselves. All of us, in spite of vigorous protestations to the contrary, do pretty well what is expected of us. Our lives are governed by a thousand rules and conventions, most of them foolish in themselves, which nevertheless must be adhered to rigidly without reason. Consider, for instance, the no doubt respectable business man whom we saw in a Pullman car the other day calmly making his way to the men's toilet devoid of coat and shirt, suspenders hanging down and carrying his shoes in his hand. His aspect was far from presentable. Yet, if this same man appeared at a social affair wearing a red tie instead of a black one, his confusion would know no bounds.

The civilized human animal is supposed to differ from other animals in the endowment of reasoning powers. Yet, if we could study the actions of human beings from a distance, knowing nothing of their natures, we would come to the conclusion that of all creatures the human being was the most unreasonable. What peculiar attribute is it in a man, for instance, to condemn the use of cigarettes by women while at the same time he consumes the better half of a 15-cent cigar? Is that reason? Again, what sort of lop-sided mental action induces a prosperous individual to tip a still more prosperous waiter a half dollar upon getting up from the table in a restaurant and then, outside on the street corner, wait for his change from a nickel from a newsboy who needs the money? Reason?

Then there is the man who, while jaywalking, narrowly escapes being hit by an automobile, spends the remaining portion of the day cussing the reckless driver and calling upon the combined police force of town and state to arrest him. What is it that, when this same person climbs behind the wheel of his own car, makes him utterly forget the pedestrians' rights and induces him to take every corner on two wheels?

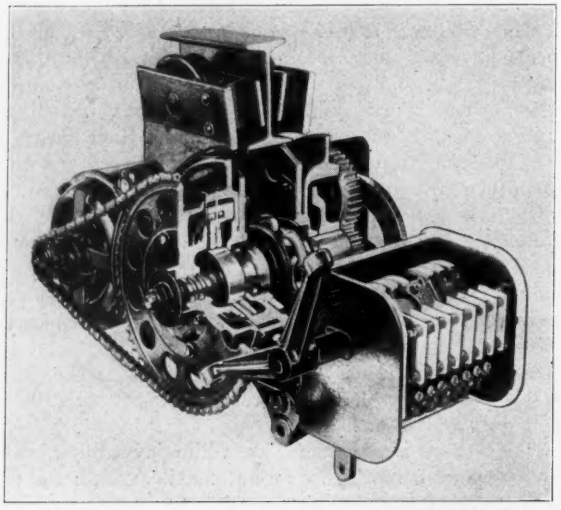
These are only a few examples of the way in which human beings make use of their reasoning powers. We could cite others which deal with his mental attitude toward certain sociologico-religious concepts which would even more forcefully prove that the reasoning propensities of the human being are largely illusionary. But here we are encroaching upon the prejudices of a world of creatures endowed with reason and history has shown that to those who value their security this is not a safe procedure. Of course, each one in reading this, automatically knows that he is an exception and so do we except ourselves in writing it. Yet the whole is made up of its component parts and, when the whole presents such a sad spectacle of unreason, we, assuming again that we are endowed with reasoning powers, can not but conclude that there is something wrong with the component parts.

So we come to the end of our complex. Our cynical mood vanishes; once more we bask in the warm spring sunshine and our thoughts dwell on the making of verses.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Electric Chain Hoist Has Ball-Bearing Load Sheave

A NEW BALL-BEARING electric chain hoist, embodying such features as close headroom, long lift, high speed, automatic top and bottom limit stops and great over-all strength, has recently been developed by



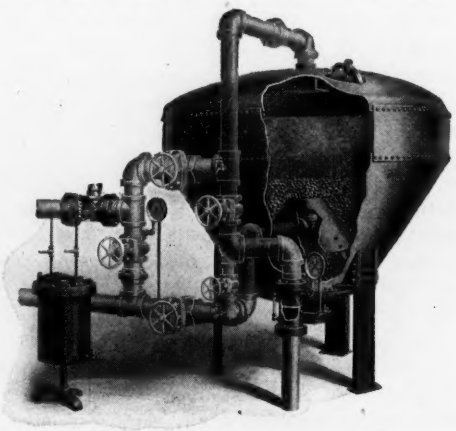
CUT-OUT VIEWS SHOW BALL-BEARING SHEAVE, PINION AND RUGGED CONSTRUCTION OF WHOLE UNIT

The Yale & Towne Mfg. Co., Stamford, Conn. This hoist, known as Model 20B, has unusual factors of safety in the strength of the load-supporting members and is designed to withstand shock loads so common to this class of equipment. All suspension members are made of the highest quality steel.

Model 20B can be quickly adapted to any overhead system. The side plates of the trolley carriage can be spaced on steel bars to fit the desired beam flange. Yale electrically welded steel chain can be furnished for varying lengths of lift. The centralized steel suspension means a constantly balanced load on the trolley wheels and hoisting unit irrespective of load position. The mechanism is fully enclosed in oil-tight chambers and is compact and easily accessible for inspection without expert service. Large chrome vanadium steel ball bearings surround the substantial steel load sheave. This one-piece load sheave, ground on an arbor to give perfect concentricity for the ball races, is bronze-bushed for the driving pinion, and splash lubrication provides a continuous flow of oil over all gears, pinions and bearings. The driving pinion that passes through the load sheave is machined from a single drop forging, then heat-treated. The bearing surfaces on the shaft are ground to 0.001 in.

Mechanical Pressure Filter Has No Strainer Heads

MECHANICAL OR PRESSURE filters are widely used for clarifying water for industrial purposes, for boiler feeding, for swimming pools, for general service supply, for cooling jackets and many other purposes. Such filters generally consist of a closed tank containing a layer of sand supported on a bed of gravel, at the bottom of which are strainer heads connecting with a pipe manifold for the withdrawal of the filtered water and for the introduction of wash water when backwashing the filter.



WATER IS WITHDRAWN FROM UNDER AN INVERTED CONE INSTEAD OF THROUGH STRAINERS

Strainers and similar internal collecting devices have a tendency to foul or clog, thus restricting the flow of water, and they also rust or corrode. Furthermore, while they serve well enough to distribute the flow uniformly, they do not entirely prevent the escape of filter sand, which may damage pumps and other apparatus.

In the operation of backwashing the sand layer is lifted slightly and held in suspension in a semi-fluid condition; this should not only cleanse the filtering medium, but should also re-sort the sand grains, leaving the finest on top. It is the upper inch or two that does most of the actual filtering. In order to secure such re-sorting, it is necessary that the velocity of the backwash water should decrease progressively from bottom to top in passing through the filter, so that the finest particles will be washed out of the lower layers and deposited in the upper layers.

In a new design of filter which has recently been developed by the Cochrane Corp., of Philadelphia, and which is illustrated herewith, strainer heads and collecting manifolds have been eliminated, but uniform distribution of the flow throughout the sand layer when filtering and uniform distribution of flow in backwashing have been secured by suitably shaping the shell or filter body. The

method of withdrawing the water also eliminates any possibility of sand passing through the filter.

The top layer of sand in this new filter is of the same character and depth as in ordinary pressure filters, the filtering rate being figured on the same basis namely, from 2 to 5 gal. per sq.ft. per min., depending somewhat on the character of the water and the service conditions. The filter body or shell is cylindrical throughout the depth occupied by the filtering sand but below this is converging or conical. Underneath the layer of fine sand are two layers of gravel and beneath that a layer of pebbles. Imbedded in the pebbles is an inverted open cone from the apex of which the water is withdrawn through a pipe. The pebbles do not extend up into the inverted cone, which is so proportioned that the velocity of the water at the plane where it leaves the pebbles is not great enough to carry out sand particles.

The velocity of the water through the gravel layer and through the pebbles is, however, higher than through the sand bed, and in backwashing all materials are lifted and semi-suspended in the up-flowing water, so that they are resorted and stratified, the finer particles being carried upward and the finest deposited on top. There is no tendency to lift sand from the top of the sand layer, as the velocity is not high enough.

This filter is regularly supplied with an orifice and differential pressure gage for measuring the rate of backwashing. Where the backwashing connection is to a closed pipe, a sight glass is also connected around the orifice plate, so that a certain amount of wash water is forced through the glass, enabling the operator to determine when the backwashing is complete.

Supports for the filter body are placed underneath the conical shell, so that filtering units can be set close together, with some saving in floor space. There is also a saving in weight, due to the smaller cubical capacity of the shell for a given area of sand layer.

To remove the filtering material, as is sometimes necessary when filtering greasy water, the sand and gravel do not have to be shoveled out but can be dropped out when the gate or door at the bottom of the filter body is opened.

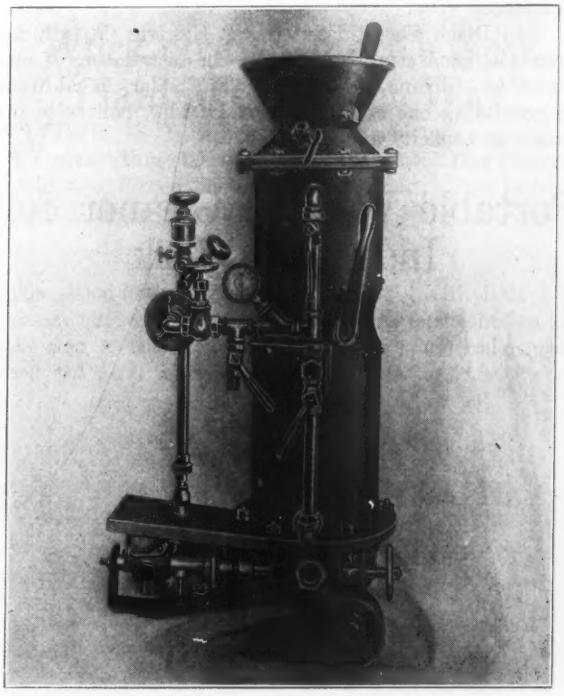
New Portable Drive for Power Pipe Tools

FOR DRIVING PIPE TOOLS, a new and lighter weight model of its Power Drive is being made by The Oster Manufacturing Co. of Cleveland, Ohio. The body of the machine is made almost entirely of an aluminum alloy. This new machine weighs only 150 lb. and is really portable as a unit, without removing any parts.

The driving power is furnished by a ½-hp. Universal, reversible motor, which automatically speeds up on the smaller sizes of pipe and holds the necessary speed on the larger sizes, giving the outfit a greater production capacity. The motor can be run on any 110 or 115-v. lighting circuit, either d.c. or a.c., single phase and of any cycle from 25 to 60. Its reversible feature makes it possible to use nearly any die stock in connection with the machine. The machine itself will drive die stocks and pipe cutters up to 2-in. capacity; with a special auxiliary drive shaft which can be furnished, geared die stocks and cutters up to 6 in. can be driven. In addition to this, the machine can be used to screw up fittings, as a pipe wrench can be held in its driving arms and revolved. The machine is 18⅛ in. high, 14½ in. wide and 30 in. long.

Small Size Cement Gun Aids Repair Work

DESIGNED to be operated with a one-drill compressor, a new small size "Cement-Gun" (trade mark), known as the Type N-00, has recently been placed on the market. This machine, shown in the accompanying illustration, is of especial advantage to general contractors for the repair and restoration of honey-combed concrete and other small patch work, as it is easily portable, weighing only 200 lb., and requires only 60 cu. ft. actual free air per minute for proper and efficient operation. These characteristics make it available for use with small size portable compressors, which are usually standard equipment on all jobs of any size. Its operation is



THIS NEW SMALL SIZE CEMENT GUN IS PORTABLE AND OPERATES ON 60 CU. FT. OF FREE AIR PER MINUTE

identical with that of the larger machines, and it offers all of the advantages of the larger machines with the exception of capacity.

This new machine, made by the Cement-Gun Co., Inc., Allentown, Pa., is also particularly adaptable for the repair and maintenance of furnace linings, and for general repairs around mines, industrial and other plants where there is a limited supply of compressed air.

Byllesby Engineering & Manufacturing Corporation Plans 1926 Construction

APPROXIMATELY $30,000,000 will be invested during 1926 in new construction, additions and extensions in plants and equipment to provide for the constantly growing demands for service at the operated public utility properties of the Standard Gas & Electric Co., according to H. W. Fuller, vice-president in charge of engineering and construction of the Byllesby Corporation.

Projects now under way or soon to be started include the $7,500,000 hydro-electric plant of the Louisville Hydro-Electric Co. at the falls of the Ohio River. It will have an initial capacity of 108,000 hp. in eight 13,500-hp. units, with provision for increasing the generating capacity to 135,000 hp.

Among the other more important projects provided for in this year's budget is the construction of the new Bayside steam station by the Wisconsin Public Service Corp. at Green Bay, Wis., with an initial installation of two 13,000-hp. generating units and three 1300-hp. boilers. The plant is expected to be ready for operation by January, 1927.

At the Horseshoe Lake plant of the Oklahoma Gas & Electric Co. a new 26,500-hp. turbine will be installed together with a 1000-hp. boiler and necessary auxiliary equipment.

San Diego Consolidated Gas & Electric Co. will increase its generating capacity by the installation of one 20,000-hp. turbine and one 1100-hp. boiler, in addition to rebuilding one of the present 1100-hp. boilers to increase its capacity and efficiency.

Portable Vacuum Cleaner for Industrial Work

IN MODERN industrial plants, as well as in hotels, office buildings and large institutional buildings, the vacuum cleaner has found many useful applications. A new vacuum cleaner, of the heavy duty portable type, has been

PORTABILITY AND RUGGED CONSTRUCTION WITH LIGHT WEIGHT ARE FEATURES OF THIS VACUUM CLEANER

placed on the market for this work. It is known as the Tabco No. 500 and is classified as coming between the small household vacuum cleaner and the extremely heavy, portable and stationary pneumatic sweeping systems for industrial work. It is suitable for light dust removal work in factories and with its blowing attachment is convenient for blowing out motors, telephone switchboards and other electrical apparatus.

Tabco No. 500, shown in the accompanying illustration, weighs 105 lb. and is mounted on a frame of heavy steel tubing with welded joints. Extra heavy wire wheels with heavy rubber tires are provided and the caster is equipped with ball bearings. The exhauster is of aluminum, of the two-stage centrifugal type with one-piece aluminum impellers. The driving motor is a ½-hp. Westinghouse unit, supplied for a.c. or d.c. at 100 to 120 v. and in the a.c. type for 25 or 60-cycle power. Special machines can be furnished for 220 v. Self-alining ball bearings with grease lubrication are used. On account of the large rear wheels, the machine is easily taken up or down stairs and is designed to be entirely portable.

This cleaning unit which is manufactured by Allen & Billmyre, New York, has a maximum capacity of about 75 cu. ft. of air a minute at a maximum vacuum of about 2.5 in. of mercury.

New Hydro Electric Project on the Mokelumne River

THE PACIFIC Gas & Electric Co. is daily expecting word from Washington that the Federal Power Commission has formally approved the transfer to the company of a license for the development of water power projects on the upper reaches of the Mokelumne River in Amador and Calaveras counties. The Pacific Gas & Electric Co. has acquired by purchase certain properties and accompanying water rights in that region in order to provide additional power and storage facilities for its Electra power system in Amador County.

Back in 1897 the Electra system was started, when the Blue Lakes Water Co. constructed a water power plant on the banks of the Mokelumne River some 4 mi. from Jackson, in Amador County, utilizing as its operating force the water supply from a cluster of lakes in Alpine County, at an elevation of 8000 ft. above sea level, in the vicinity of Border Ruffian, the highest peak in the Sierra Nevada range. The first power plant was destroyed by fire 2 yr. later, but was rebuilt and was operated up to 1902, when the Standard Electric Co., predecessor in interest of the Pacific Gas & Electric Co., having taken over the properties of the Blue Lakes Water Co., constructed the present Electra power house on a much larger scale than the other. To the original sources of water supply, known, respectively, as Upper and Lower Blue Lakes, Twin Lakes and Meadow Lake, was added a reservoir formed by damming the Bear River, a tributary of the Mokelumne. These various reservoirs discharge into the Mokelumne River, whose waters are diverted into two canals at a point about 20 mi. above the Electra power house and have been used for the past 20 yr. to operate this plant with its installed generating capacity of 26,000-hp.

Originally the Blue Lakes installation was made primarily for supplying electric power to the mines in the Mother Lode section running through Amador and Calaveras Counties; but, later, when the larger Electra plant was installed, the transmission lines were extended to Stockton, thence to San Francisco, so that the greater part of the output of Electra is now supplied to valley consumers, aiding in the prosecution of industrial as well as agricultural enterprises.

Work expected to be undertaken will involve the construction of a dam on the Mokelumne River, at Salt Springs, approximately 4 mi. up stream from the junction of the river with its principal tributary, the Bear, which flows in from the northward. The damsite is at an elevation of 3800 ft. above sea level and lies in a granite country that is typical of the Sierra Nevada range. Cliffs in excess of 1000 ft. in height rise from the stream on either side of a narrow gorge. The dam itself will be 200 ft. in height, of rock-fill formation with concrete face, and will require 1,000,000 cu. yd. of material for its construction. It will impound the waters of the river

to the extent of creating a reservoir of 60,000 acre-feet capacity. From an intake at the dam the water from the Mokelumne will be conveyed by concrete lined canal and tunnel along the northern slope of the stream a distance of 25 mi. to Tiger Creek, and from that point will be dropped 1200 ft. to operate a new power house whose electric generating capacity will be around 40,000-hp. Having performed this service, the water will be carried on to Electra power house. Work will be started as soon as the necessary authority is given.

Five Special Trains to the N. E. L. A. Convention

ALL TRANSPORTATION arrangements for the annual convention of the National Electric Light Association to be held at Atlantic City, New Jersey, May 17 to 21, have been completed. For the convenience of the members and guests who desire to travel *to and from* the convention without change of cars, five special trains will be operated. These are designated respectively as the Western Special, Central Special, Southern Special, Chicago Special and the New England Special.

The Western Special will be composed of Special Cars operated on limited trains from Portland, Ore., San Francisco, Cal., Denver, Colo., Omaha, Neb., Topeka, Kan., St. Paul, Minn. and Milwaukee, Wis., which will be assembled at Chicago, Ill. and run as special train to Atlantic City, leaving Chicago (Penn. Station) at 12:50 p. m. (Central Time) Saturday, May 15. The return trip will be the reverse of the going trip, leaving New York (Penn. Station) at 1:55 p. m. (Eastern Standard Time) Tuesday, May 25.

The Southern Special will be composed of Special Cars operated on limited trains from New Orleans, La., Montgomery, Ala., Atlanta, Ga., Nashville, Tenn., Louisville Ky., and Charleston, W. Va., which will be assembled at Washington, D. C. and run as a special train to Atlantic City, leaving Washington, D. C. at 8:00 a. m. (Eastern Standard Time) Sunday, May 16. The return trip will be the reverse of the going trip, leaving New York (Penn. Station) at 5:45 p. m. (Eastern Standard Time) Tuesday, May 25.

The Central will be composed of Special Cars operated on limited trains from Houston, Tex., St. Louis, Mo., Indianapolis, Ind., Detroit, Mich., Toledo, O., and Cleveland, O., which will be assembled at Pittsburgh and run as a special train to Atlantic City, leaving Pittsburgh at 3:51 a. m. (Eastern Standard Time) Sunday, May 16. The return trip will be the reverse of the going trip, leaving New York (Penn. Station) at 1:05 p. m. (Eastern Standard Time) Tuesday, May 25.

The Chicago Special will leave Chicago (Pennsylvania Station) at 1 p. m. (Central Time) Sunday, May 16, arriving in Atlantic City at 9:45 a. m. (Eastern Standard Time) on Monday. On the return trip it will leave Atlantic City at 3:40 p. m. (Eastern Standard Time) Friday, May 21 and will arrive in Chicago at 10:05 a. m. (Central Time) Saturday, May 22.

The New England Special will operate over the New York, New Haven and Hartford Railroad, leaving Boston (South Station) at 10:45 p. m. (Eastern Standard Time) Sunday, May 16. On the return trip it will leave Atlantic City at 9:30 p. m. (Eastern Standard Time) Friday, May 21. A special car will be operated from Springfield, Mass., leaving 11:20 p. m., May 16, and arriving back 6:40 a. m., May 22.

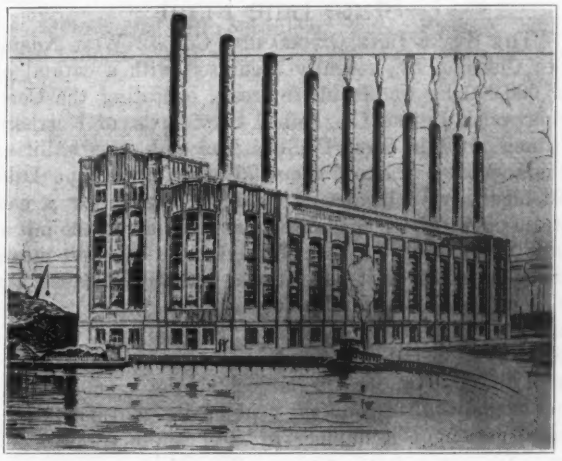
In all cases application for accommodations on these various trains will be honored in the order of their receipt and the Master of Transportation will be forced to decline to accept any applications received after May 1.

Delegates traveling on the Western, Central and Southern Specials, which return from New York City, have the option of leaving Atlantic City for New York whenever they may desire.

Applications for accommodations on all specials should be sent to Robert B. Grove, Master of Transportation, Room 614, 130 East 15th street, New York City.

Work on Baltimore's New Plant Well Under Way

WORK IS WELL under way on the new steam generating station of the Consolidated Gas Electric Light and Power Co. of Baltimore, Md. This station, which is being erected at Gould and McComas streets,



THE TURBINE AND BOILER ROOM BUILDING. GOULD STREET STATION AS IT WILL APPEAR WHEN COMPLETED

Baltimore, it is planned will begin generating in September, 1926.

The initial installation will be 48,000 hp., to be followed by additional generators, giving Gould street station a capacity of 192,000 hp.

In Baltimore, the growth of the electrical load required frequent additions to the generating capacity of the electrical system during the past few years. The Westport station, to which frequent additions had been made, was finally brought to its maximum capacity by the installation of two 20,000-kw. generating units in 1924.

Additional generating capacity was found necessary for the fall of 1925 and over a year and a half ago the company was ready to begin construction on a new plant at Gould street. The Pennsylvania Water and Power Company, however, planned to erect its steam station at Holtwood for operation in the summer of 1925 and agreed to furnish a minimum of 12,000 kw. on the peak

to the Gas and Electric Co. throughout the four months of September to December, 1925. This arrangement deferred the construction of the Gould street plant for about one year.

The new plant will be a thoroughly modern plant of advanced design, giving superior economies and comparing favorably with some of the best stations in the country. These economies will be obtained by the use of unusually large boilers fired with pulverized coal. The steam pressure will be 425 lb. or slightly higher and the steam temperature about 735 deg. F. Air preheaters will be used and the turbines will be of the bleeder type, heating the feed water to about 370 deg. F.

The Gould street plant will be on the site of the old Baltimore Electric Company plant. The old boiler house will be used for a coal pulverizing plant, a purpose for which it is well adapted. The turbine room will be used as a machine shop. The new station will extend from the river's edge and will extend toward McComas street, as additions are made. Water front property in Baltimore is valuable and the Gould street site has the advantage of being even nearer the load than the Westport station.

Insull Interests Plan 1,000,000-Kw. State Line Plant

THE STATE LINE GENERATING CO., 72 West Adams St., Chicago, Ill., recently organized with a capital of $5,000,000 by the Insull interests, operating the Commonwealth Edison Co., Public Service Co. of Northern Illinois, Middle West Utilities Co., and other utilities, has selected a tract of about 75 acres of land on Lake Michigan, near Hammond, Ind., as a site for a new steam-operated electric power plant. Work on the initial unit will be started at an early date; the first steam turbo-generator unit will have a rating of 200,000 kw. This will be a compound unit consisting of three turbines and their generators; four additional units of the same size will be installed later, giving a total station capacity of 1,000,000 kw., or the largest single steam-operated power plant in the country. The project will include the construction of a number of steel tower transmission lines for service to the various affiliated companies in the Chicago-Illinois-Indiana industrial districts. The new organization will engage in production only, and will be headed by Samuel and Martin Insull, Britton I. Budd and E. W. Lloyd, all of Chicago; Harry Reid, president of the Interstate Public Service Co., Indianapolis; Charles W. Chase, president of the Gary Railways Co., Gary, Ind., and others.

Union Carbide Company Plans Hydro Development

THE UNION CARBIDE CO. has applied for a preliminary permit for a project on Clinch and Powell Rivers and their tributaries, in Roane, Loudon, Anderson, Knox, Campbell, Union, Claiborne, Grainger and Hancock Counties, Tenn., and Lee and Scott Counties, Va. The plan of development involves four damsites at Senator site on Clinch River just above Emery River in Roane County, with a navigable pool extending to damsite No. 2, to be at Melton Hill site on Clinch River in Anderson and Knox Counties, with a navigable pool extending from this dam to a point about 37 mi. farther up the river.

Dam No. 3 is to be at Clinton site on Clinch River in Anderson County, near Clinton, with a navigable pool extending to Cove Creek damsite (No. 4). This damsite will be about 8 mi. north of Clinton in Campbell and Anderson Counties, and will create a lake about 82½ sq. mi. in area. The developed heads at the dams will be about 36, 60, 15 and 225 ft., respectively. About 293,000 hp. is proposed to be developed and is to be used for commercial purposes.

San Joaquin Light & Power Corporation to Complete King's River Project

AT ITS MEETING ON January 28, 1926, the Federal Power Commission, Washington, D. C., authorized amendment of the license issued to the San Joaquin Light & Power Corp. on July 28, 1922, for the project designated as No. 175 so as to include its developments on the Upper North Fork of King's River, in California.

The new works will consist of four dams, known, respectively, as the Helms dam, the Upper North Fork diversion dam, the Fleming Creek diversion dam, and the Post Corral dam, two water conduits having a total length of about 10 mi., and a power house known as the Helms power house located near the upper end of Lake Wishon. The Helms dam will be a constant-angle-arch, concrete structure about 297 ft. high., creating a reservoir of approximately 102,000 acre feet. The Upper North Fork diversion dam will be a rock-fill dam, with a total length of about 1375 ft. and a crest width of 12 ft. The Fleming Creek diversion dam will be a rock-fill structure having a maximum height of about 66 ft. and crest length of 985 ft. The power house installation will consist of three 13,600-kv.a. generating sets, direct connected to overhung impulse turbines.

A.S.T.M. Committees Report Progress

AT THE PROVIDENCE BILTMORE, Providence, R. I., the fifth group meeting of the committee of the American Society for Testing Materials was held on March 17, 18 and 19, in which 13 committees took part. Committees on steel, wrought iron, corrosion, electrical and industrial products and others reported progress. In addition, meetings were held of the Joint Research Committee of the A. S. T. M. and the A. S. M. E. on the Effect of Temperature on the Properties of Metals. The meetings were attended by about 350 members and guests representing the various industries concerned.

Of special interest to power plant men was the report of the subcommittee on pipe flanges and fittings for high temperature service. It was decided subject to confirmation by letter ballot, to recommend acceptance of both specifications as tentative by the society.

British Form New Research Organization

FORMATION OF AN ORGANIZATION to deal with all questions of fuel technology, with the object of making more efficient use of fuel resources was decided upon at a meeting recently held in London, England.

Sir William J. Larke in opening the proceedings said that none of the existing institutions undertook work of the precise kind which was in the minds of those who were concerned with the organization of the Institution of Fuel Technology.

News Notes

SARCO CO., INC., New York City, moved its headquarters on March 31 from the Woolworth Building to 183 Madison Ave., where the warerooms of the company will also be located.

GIRTANNER ENGINEERING CORP., manufacturer of pipe line conveyors, announces the removal of its general offices from 1400 Broadway, New York City, to 122 Greenwich St.

THE STEPHAN CO., 7016 Euclid Ave., Cleveland, O., has undertaken the representation of the Prat-Daniel Corp., New York City, manufacturers of the Thermix Air Preheater and the Stream-Line Stack for induced draft.

E. O. SHREVE, manager of the San Francisco office of the General Electric Co. since 1918, has been named manager of the industrial department of the company with headquarters at Schenectady, filling the vacancy caused by the recent death of A. R. Bush.

WILLIAM S. JOHNSTON, formerly with Ford, Bacon & Davis, Inc., is now with Stevens & Wood, Inc., New York City. While with Ford, Bacon & Davis, Mr. Johnston was mechanical designer of the Sterlington power station of the Louisiana Power Co. and placed the station in commercial service.

JOHN V. CALHOUN, formerly engineer of furnace construction with Combustion Engineering Corp., New York City, has taken up his new duties as sales manager with Harold E. Trent, manufacturer of electrical heating and temperature control appliances, Philadelphia, Pa.

ORTON & STEINBRENNER, Chicago, Ill., manufacturer of Orton cranes and material handling equipment announces that the company name has been changed to Orton Crane & Shovel Co. The same products will be manufactured and the address of the company will remain the same.

ANNOUNCEMENT HAS BEEN MADE of the appointment of Harlan A. Pratt as manager of the oil and gas engine department of the Ingersoll-Rand Co. Mr. Pratt was connected for many years with the sales department of the Westinghouse Electric & Manufacturing Co., later becoming sales manager of the Atlantic Elevator Co.

JAMES R. ANDERSON, traveling representative of the Lunkenheimer Co., Cincinnati, Ohio, passed away on Monday, March 15. Mr. Anderson was born in Scotland in 1864, and when fifteen years of age he came to this country. In 1894 he became connected with the Lunkenheimer Co. He was located in New Orleans for many years and later removed to Cincinnati.

ON JANUARY 1, 1926, THE MOTOR DIVISION of the Wellman-Seaver-Morgan Co., of Cleveland, Ohio, operated at Akron, Ohio, was purchased in its entirety by the Sanderson-Cyclone Drill Co. of Orrville, Ohio. All former heads of the engineering and manufacturing departments of the motor division of the Wellman-Seaver-Morgan Co., are retained in the same capacities.

DAY & ZIMMERMAN, INC., ENGINEERS, announce the opening of a foreign office at Paris, France, in charge of Robt. D. McCarter, vice-president. Mr. McCarter has conducted important engineering work in Europe for various American companies, has been consulting engineer for English and Continental public utilities and for a time served as Honorary Secretary to the Commission for Relief in Belgium. By means of the new organization, Day & Zimmerman, Inc., is now prepared to make investigations, reports and valuations of industrials and public utilities abroad.

S. C. BLOOM, for many years identified with the Atmospheric Conditioning Corp. as vice-president and Western manager, with headquarters at Chicago, has acquired the Webster Brine Spray, also the brine spray refrigeration and packing house air conditioning business formerly handled by Atmospheric Conditioning Corp. Mr. Bloom will carry on his business under the name of S. C. Bloom & Co. and will continue to maintain offices in the Monadnock Block, Chicago. In addition, the company will manufacture several articles of allied equipment designed by Mr. Bloom.

GOULDS PUMPS, INC., will be the new name of the company—formerly the Goulds Mfg. Co.—which has been manufacturing Goulds pumps for 57 yr. It is a change in name only, as ownership, direction and management will be in the hands of the same men as heretofore. The works will continue at Seneca Falls, N. Y., and the branch offices will be continued with the same personnel.

AT A MEETING OF THE BRIDGEPORT BRASS CO. held Tuesday afternoon, February 23, Warren D. Blatz, general sales manager, and Walter R. Clark, general works manager, were appointed to the board of directors. The selection of the two men as directors is in public recognition of their ability and rapid rise in the ranks of chief executives of the firm.

PATTERSON-KELLEY CO., New York, has acquired the business of the Stewart Heater Co., formerly of Buffalo, N. Y., which manufactured the Otis heater. The new owner announces that all types of Otis heaters will continue to be made and that repair parts for Otis heaters can be supplied promptly.

ANNOUNCEMENT IS MADE of the foundation of Hall Laboratories, Inc., with Ralph E. Hall, Ph.D., formerly physical chemist at the U. S. Bureau of Mines as director. This new organization, with headquarters at 304 Ross St., Pittsburgh, Pa., will serve as consultants in the application of recent discoveries to the elimination of scale and corrosion in steam plants.

PACKARD ELECTRIC CO. announces the appointment of Howard B. Johnson as representative of its transformer division in the Chicago District. Mr. Johnson succeeds L. H. Alline, who recently resigned to accept a position as general manager of the Maine-New Brunswick Power Co. with headquarters at Presque Isle, Me.

THE NEW YORK STATE WATER POWER COMMISSION, Albany, N. Y., has been holding a series of hearings on applications for permission to carry out hydro-electric power projects on the St. Lawrence River in the northern part of the state. The main applicant has been the Frontier Corp., a holding company for the St. Lawrence Valley Power Corp. and the Louisville Power Corp.; the Frontier organization is controlled, in turn, by the Alumi-

num Co. of America, E. I. du Pont de Nemours & Co., and the General Electric Co. The request of power permits covers a number of sites, with potential horsepower estimated at close to 1,000,000 for plant capacities. Another application is being considered by the Commission from the Lower Niagara Power & Water Supply Corp., for permission to proceed with a development on the gorge, below Niagara Falls, with capacity estimated at 300,000 hp.

At Aroostook Falls on the Aroostook River the Maine & New Brunswick Electric Co.'s plant has been purchased by the Pierce Engineering Co., Chicago, which has taken possession. The same company has also purchased the Gould Electric Co. at Presque Isle, Me.

The board of directors of the Wm. Powell Co. announce the election of H. H. Coombe as president and treasurer of the company on March 9, 1926. Mr. Coombe has been associated with the company for many years, serving as vice-president and treasurer since 1912. He was originally elected a director in 1902. Other officers elected were James Coombe, vice-president and general manager, and Geo. E. Weitkamp, secretary.

The Carolina Power & Light Co., Raleigh, N. C., recently formed by a consolidation of five power utilities in this section, has authorized plans for the construction of two new hydro-electric power plants. One of the stations will be on the Yadkin River, near Norwood, N. C., designed with an initial capacity of 63,000 kw., to be extended later to about 85,000 kw. The other plant, on the Pigeon River, about 15 mi. from Asheville, N. C., will have an initial capacity of 50,000 kw., and a rating of 75,000 kw., when completed.

The Texas Central Power Co., San Antonio, Tex., has just begun work on an addition to its light, power and ice plant at Victoria, Tex. One 3000-kw. Westinghouse turbo-generator will be installed, together with two 750-hp. Stirling boilers with superheaters. These boilers will be oil fired and steam will be superheated about 220 deg. Sargent & Lundy, Inc., Chicago, are consulting engineers for this work and Lee M. Beall, of that company, is resident construction engineer. W. C. Welborn is chief engineer of the power company. The new plant at Victoria is expected to be in operation in the fall of 1926.

Books and Catalogs

Handbook of Steam Engineering. By W. E. Biggs and W. R. Woolrich, Knoxville, Tenn.; 377 pages, 4½ by 7 in., imitation leather; price, $2.

For the man who wants to know why and how, yet is somewhat handicapped by a limited technical education, this handbook will give much valuable information. It is divided into 38 chapters and has a well selected alphabetical index of all subjects discussed. Some of the more important chapters are devoted to: heat; fuels and combustion; grates and stokers; steam boilers; steam engines; steam turbines; pumps; condensers, drafts and chimneys; water softeners, and packing materials.

Announcement is made that a section of the A. S. M. E. Boiler Construction Code that has created a great deal of interest during the formulative period is Section VII on Suggested Rules for the Care of Power Boilers, which has been formally approved by the council and is now on the press. The demand for this new Code is great from all parts of the world, even in advance of publication, and every effort is being made to hasten its issuance. It will comprise a pamphlet of about 80 pages and will soon be ready for distribution.

Information on the analyses, heating values and general characteristics of numerous Missouri coals are given in Technical Paper 366, just issued by the Bureau of Mines, Department of Commerce. The coal reserves of the State of Missouri, before mining began, have been estimated at approximately 79,000,000,000 t. The paper contains chapters on the topography and geology of the coal areas of Missouri and on mining methods practiced in the state. It is the ninth of a series containing information on the characteristics of coals mined in various states. Copies of Paper 366 may be obtained from the Superintendent of Documents, Washington, D. C., at 10 cents each.

Bulletin No. 7, containing interesting information on Walworth Sigma steel valves and fittings, has just been issued by Walworth Co., Boston, Mass. The bulletin contains detailed lists of materials used in the different classes of valves, together with recommendations for standard service conditions, figure numbers for all valves, specific service recommendations and general dimensions for each series and type and the same information for Walworth Sigma steel fittings. Some discussion of preparation of Sigma steel is also given.

The new Republic motor driven CO_2 recorder is completely described in a bulletin just issued by the Republic Flow Meters Co., Chicago, Ill. After discussing some of the fundamentals of combustion, the bulletin describes the construction of the new recorder, emphasizing particularly the rugged construction of the recorder which includes many parts of tool steel, heavy brass and bakelite or fibre gears where necessary to reduce vibration and noise.

Separator magnets for removing tramp metal from various classes of material passing over conveyors are described in a bulletin recently received from The Electric Controller & Mfg. Co., Cleveland, Ohio. Interesting photographs show how the separator magnet manufactured by this company is applied to different types of cinder, ore, coal and stone conveyors and some discussion of these applications is given in the text.

Combustion Engineering Corp., Broad St., New York, in a well illustrated and pleasingly arranged letter size catalog U-1, describes the C-E unit system for burning pulverized fuel. Details of construction of the impact mill are given and illustrated diagrams of installations and discussion of furnace design for use with the unit pulverizer are of interest.

Wilson-Snyder barge pumps, designed and built for barge service, are described in a bulletin recently issued by Wilson-Snyder Mfg. Co., Pittsburgh, Pa. These pumps are designed for rapid loading and unloading of oil barges and several illustrations of their application to this work using various types of drives are given in the bulletin.

"Electric Heat in Industry" is the title of a 32-page bulletin just issued by the General Electric Co., and bearing the number GEA-261. This bulletin deals with the advantages of electric heat for various industrial applications.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

What Price Inefficiency?

Distant El Dorados have put whole nations in ferment, caused armies of men to defy death and to undergo untold hardships in search of easily gained fortunes.

Yet there have ever existed greater opportunities to gain fame and fortune in the peaceful pursuit of industry and the conduct of everyday human activities.

For every "forty-niner" who won wealth in actual gold from the West there are many 'seventy-niners" who have gained fame and fortune from the steady upward growth of our own great industry since that first manifestation of power glowing in a glass bulb forty-seven years ago.

Within a scant half century power has created wealth greater than that derived from all the gold strikes and no trails marked with bones are left by its development.

Brains and genius greater than that of a thousand generals plan for and guide the armies of men engaged in power generation and distribution. Luxuries and comforts beyond those dreamed of by conquering nations have been given to the people of today by power.

Similar advancement has been made in all modern industries but none greater than the progress made in power generation, which progress is necessarily a basic factor in industrial progress.

At the highest point of history in the use of power, in the economy of its generation and in the demand for its expansion, power plant men see immediate potentialities greater than all the achievements of the past.

For generations events had shaped conditions to make this the age of most intense conflict between the old and the new, between efficiency and inefficiency, between proved accomplishment and the general application of successful improvements.

Silently and unnoted in the hurry of everyday life there is a veritable stampede in the minds of men—a race toward the modern treasures that lie all about us.

As the pages of this publication unfold the engineering facts of this plant's higher operating record or that machine's achievement in lowering costs, the thoughts of executives, in thousands of plants, turn to the possibilities of obtaining like gains in their plants.

In this respect the advertisements in this publication are charts to a wealth of time for the engineer now lost in unnecessary trouble and labor, and of recoverable energy to be obtained from the fuel he buys and the plant he operates.

To ownership, this wealth that may be obtained from plant improvements may be easily translated into dollars and cents.

Engineers are talking to capital and its representatives in terms of investment value, and capital itself is responsive to engineering facts.

Back of capital and all the power of control in human affairs it represents, stand the people. From them capital is recruited.

On their favor depends the profit or loss in its employment. And the people are coming to know power and the part it plays in their work, earnings, comfort and lives.

No longer are there doubtful, hesitating questionings as to whether or not service or the means of obtaining it shall be efficient.

The dominating question that every man must stand ever ready to answer is: "What price is being paid for inefficiency?"

Dollars, plants, prime movers, steam traps or a barrel of oil—each is accountable for its usefulness in relation to its cost and all men are responsible for whatever units of these that they buy and use.

Study the information given here in the light of the fact that these products are producing overall plant efficiencies which are the principal factors in reducing the rates on the millions of dollars in bond issues being offered from time to time by power, heat and light companies.

Here are advertised the means to higher efficiencies. Ask of each piece of present equipment in your plant, "What price inefficiency?"

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allen & Billmyre Co., Inc., New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Nordberg Mfg. Co., Milwaukee.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros Co., Chicago.

AIR FILTERS.
Allen & Billmyre Co., Inc., New York.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Burke Engineering Co., Holland, Mich.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveycrs Corp. of Amer., Chicago.
Hagan Co., George J., Pittsburgh.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Hagan Co., George J., Pittsburgh.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH TANKS
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.

BABBITT METAL.
Magnolia Metal Co., New York.

BEARING METAL.
Magnolia Metal Co., New York.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.

BELTING.
Goodyear Tire & Rubber Co., Inc., Akron, O.
New York Belting & P'k'g Co., New York.
Pioneer Rubber Mills, San Francisco
Quaker City Rubber Co., Philadelphia.
United States Rubber Co., New York, N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Air Preheater Corp., The, New York.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Allen & Billmyre Co., Inc., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, STEAM.
Schutte & Koerting Co., Philadelphia.

BLOWERS, TURBINE.
Allen & Billmyre Co., Inc., New York.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CASING.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER COVERINGS.
Celite Products Co., New York.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.
Scaife & Sons Co., Wm. B. Pittsburgh.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 164

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor, Del.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Nuway Boiler & Engineering Co., Chicago.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw.

BOOKS AND SCHOOLS.
McGraw - Hill Book Co., Inc., New York.

BREECHINGS.
Littleford Bros., Cincinnati, O

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO AND MOTOR.
Calebaugh Self-Lubricating Carbon Co., Inc., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Fuller - Lehigh Co., Fullerton, Pa.
Hills - McCanna Co., Chicago.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT GUNS
Cement-Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Johns-Manville, Inc., New York.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CIRCUIT BREAKERS.
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Fairbanks, Morse & Co, Chicago.
Hagan Co., George J., Pittsburgh.
Link-Belt Co., Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.